SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXXVI]
NUMBER 2220]

★ NEW YORK, JULY 20, 1918 ★

[10 CENTS A COPY
$5.00 A YEAR

From a picture by an Italian artist

Bringing up the guns over wonderfully constructed roads

ENGINEERS IN THE WAR

The Green Leaf

Its Scientific and Economic Exploitation

THROUGHOUT the unnumbered ages which have witnessed the rise and fall of successive civilizations upon this planet, the one thing that has stood between mankind and extinction by lack of food has been the activity of the chloroplast of the green leaf. Perhaps, before equal time has again rolled over the world, the synthetic production of food may have been achieved, and man in all his intellectual glory may claim equality with the lilies of the field. Until then the fixation of organic carbon by "photosynthesis" in green cells must, by us, be regarded as the basal chemical happening of our planet. Thousands of years of empiric agriculture have enabled man to exploit this aspect of vegetation with remarkable success, but the problem of carbon assimilation found its way into the laboratory only at the end of the eighteenth century by the genius of Priestley, and its broad aspects were first formulated by the widsom of De Saussure in 1812.

We may consider in this article what progress has been made with this matter, as a problem of pure and applied science, in the century that has elapsed since then. The recent appearance of a summary review of our knowledge of the subject by I. Jorgensen and W. Stiles[1] gives a good foundation for such consideration.

Investigators have not been idle. The bibliography contains 250 entries, but these are not a tenth of the papers published, for our authors' intention is to ignore historical development and give only a critical account of those researches which mark the present advance line of knowledge on the many separate, but converging, roads by which this well-defended secret of Nature has been attacked. The authors are as severely critical as the commissioners on a military campaign. They have carefully thought over the aspects of the subject as one connected whole, and are impatient of the many individual attacks which have wasted half their effort by failure to keep contact with flanking movements by workers coming from other directions, who should be regarded as allies, but are often treated as rivals. This report ought to have a valuable effect in unifying research activity. No similar presentation of the subject has appeared before in any language.

A century of laboratory attack has driven several salients forward, of which perhaps three stand out conspicuously. We may briefly consider how far each has progressed, as reported in this pamphlet, and what may be expected of the future. These advances concern (1) the pigments of the leaf (chap. ii.); (2) the products of carbon assimilation formed in the leaf (chap. v.); and (3) the influence of external factors on the rate of carbon assimilation (chap. iv.).

In chap. vii. will be found set out those speculations that have any significance as theories of the assimilation process. During the process that takes place in the illuminated green cell, whereby carbon dioxide disappears and sugar appears, it is clear that, somehow or other, reduction and "synthesis" must take place; but even now it is quite unclear to what system of reactions this result is to be attributed. Many hypotheses have been put forward, and Baeyer's "formaldehyde theory" has been almost canonized as an eternal verity, yet there is really no good evidence for it. Its perennial attraction no doubt is due to its æsthetic simplicity. It appears now that the reaction must be much more complex (unless, as is possible, we are entirely on the wrong tack), and this is our excuse for the slowness of progress. A knowledge of the reacting system at work would be equivalent to storming the citadel of the whole defence, but so far no one has advanced a satisfactory hypothesis that can be put to the proof of experiment. We have still to advance by slow hammering tactics from various directions.

The advance that has been made in elucidating the nature of the pigments of the green leaf under the guidance of Prof. Willstätter really amounts to a shock attack, so continuous and rapidly widening has been the progress.

In 1864 Sir George Stokes stated that he had proved that the green matter of leaves consisted of two green and two yellow pigments, though he never published his evidence. In the last decade this conclusion has been finally established by the monumental research of Prof. Willstätter and his colleagues. Before Prof. Willstätter there was no clue to the real chemical nature of these two green pigments, and it could be hoped that when their chemistry was known the process of reduction of carbon dioxide would be elucidated.

[1] "Carbon Assimilation: A Review of Recent Work on the Pigments of the Green Leaf and the Processes Connected with Them." By Ingvar Jorgensen and Walter Stiles. *New Phytologist* Reprint, No. 10. P. 180.

The curious nature of the green and yellow pigments is now made quite clear; the greens are esters of a big alcohol molecule, phytol, and a tricarboxylic aicd based on a nucleus of four pyrrole rings. Magnesium is also an essential constituent, not electrolytically dissociable, but believed to be directly united with the nitrogen. The difference between the two green pigments is simply this, that "chlorophyll *b*" contains one atom more of oxygen (and two less of hydrogen) than "chlorophyll *a*." In complete contrast to this complexity is the simplicity of the yellow pigments; "carotin" is an unsaturated hydrocarbon, and "xanthopyll" an additive oxidation derivative of it. Both the yellows, when isolated from the cell, spontaneously absorb oxygen in abundance. It is easy to assume that these differences of oxygen-potential occurring within both the green and the yellow pairs are significant for the reduction of carbon dioxide; but there is no evidence on this point at present.

A second line of attack into which much work has been put is the determination of the nature and amount of the carbon-containing substances which arise in the leaf as CO_2 disappears. Is the CO_2 quantitatively reduced to its theoretical yield of carbohydrates, or do other substances arise in "multiple photosynthesis?" The measurement of the CO_2 intake by the green leaf is not difficult, but difficulties attend the correction of this apparent photosynthesis for the amount of CO_2 simultaneously produced in the body of the leaf by respiration —an amount which is large at high temperatures, but must be known and added in for exact statements of photosynthesis. At the other end of the reaction the determination of the carbohydrates produced continues to present considerable difficulties, so that no one has yet managed to measure in one experiment both the initial CO_2 used up and the final carbohydrates produced whereby we might judge of their equivalence. Much discussion has taken place on the question of what is the first sugar to appear in photosynthesis, though this is largely a strife of ideas rather than of facts.

The identification and accurate determination of individual sugars and polysaccharides in a mixture of such bodies form a special field of analytical work the difficulties of which have been much lightened by recent English researches, set out in chap. v.; but these have not been fully overcome yet. Further, these caborhydrates have all to be extracted from the leaf unaltered by the enzymes that lie in wait for them in the cell, and finally not one determination, but two differential determinations are required to establish changes due to photosynthesis; one, at the beginning of the experiment, being on some other area of leaf that can be held to furnish a strictly comparable control. Progress in this important line of work waits upon absolutely trustworthy methods of extraction and analysis of carbohydrates.

The third significant advance that has been made is that towards an understanding of the influence and mode of interaction of the many external and internal factors that can influence the rate of photosynthesis. The control or measurement of the external factors of illumination (sunshine or artificial light), temperature, and CO_2 supply require elaborate apparatus and considerable physical experience in the fields of radiometry, photometry, scientific illumination, thermo-electric measurement of leaf temperature, etc. Of internal factors the amount of chlorophyll and the degree of openness of the stomata are sometimes significant.

When the magnitudes of the three external factors are known or controlled, there arises the important question of the nature of their interaction when the magnitudes of them vary independently—a problem which has been elucidated largely by English investigations. In any possible combination of these factors, the rate of photosynthesis at any moment is not an expression of their combined magnitude, but only of the magnitude of a particular one of them acting as a "limiting factor" to the rate of functional activity. Which of the factors happens to be the limiting factor in any combination of them can be determined experimentally by application of the principle that increase of the magnitude of the limiting factor, and of this factor only, can increase the rate of photosynthesis.

With high rates of photosynthesis, yet a new factor has to be brought into account, as internal causes produce a regular falling off of the power of photosynthesis from moment to moment of time. Until the internal causation of this is fully explained it may pass by the non-committal name of the "time-factor."

There is yet another important aspect of our attack on the problem of photosynthesis which is still in its infancy, and that is the "energetics" of the process, dealt with in chap. vi. of the pamphlet.

The essential human value of the chloroplast activity lies, of course, over and above the indispensable accident that its products are edible, in the high energy content of these carbohydrates. Therefore, the energetic aspect of the process is the fundamental one, and the whole problem should be investigated on this basis. This involves measurement of the energy incident on the high leaf-surface, with determinations of the amount transmitted, or reflected, or used in transpiration, as compared with the fraction store up in photosynthesis, which last finds expression in the increased heat of combustion of unit-area of leaf-surface enriched by carbon assimilation. In this field of work progress can be made only by elaborate physical apparatus and critical determination of physical constants.

Let us now turn to the economic aspect of photosynthesis regarded as a problem of industrial or applied science. In these times, when cereal food supply threatens to become a limiting factor to the endurance or free existence of nations, the question of what science can do to multiply the number or heighten the activity of the chloroplasts subserving the cause of humanity acquires a poignant interest.

It cannot be said that the physiological study of chlorophyll activity has yet enabled any improvement to be made in the allied science of agriculture. The conditions of present-day agriculture are too little intensive, and not yet such as to make it worth while to attempt to exploit the researches of plant physiologists. Cultivation of new acreage, selection of types, and increase of transport facilities are the present solutions of the limitation factor of carbohydrate food supply.

The utilization of researches on the augmentation of photosynthesis would be of profound importance in the imaginary case of a self-contained or strictly isolated community of limited acreage, a wealthy and intelligent community with a large population on a small area of soil for sunshine or artificial illumination. Their problem would have to be solved on the basis of investigations on the factors controlling photosynthesis of the type we have already mentioned.

In such a community the relation between plant physiology and agriculture would become something like that holding now between human physiology and medicine. Today every progress in human physiology is eagerly correlated with medicine, and lavish endowment and encouragement are extended to pure physiological science on account of its generally recognized applicability to medicine. The outlook of medicine and hygiene is, however, individual, and not commercial; there is a desire to save every life and continue the activity of every individual, however worthless it may be to the community. With agriculture and plant communities there is no such outlook, and with regard to any application of plant physiology it is required that the intensification of the synthetic activity of the plant aimed at shall pay economically.

We see then, that it is probable that the main cereal crops will for a long time be left to the mercy of natural vagaries of light, heat, water, and carbon dioxide, but minor activities of intensive food cultivation are now utilizing deliberate or unconscious control of one or more of the factors of photosynthesis. It becomes, therefore, highly important that there should be carried out a comprehensive investigation of the physiology and energetics of carbon assimilation dealing with the possibilities of intensive photosynthesis under all artificial combinations of factorial conditions. From what we have said as to the complexity of this matter it is clear that no one or even two investigators are likely to have all the special chemical, physical, and physiological experience required for rapid progress, so that this would have to be an organized combined research, and continued over a number of years with good equipment and liberal endowment.

In conclusion we may express the opinion that, in the eyes of all who know the results of modern work on chlorophyll, Germany has acquired lasting credit for her great achievement with this difficult and elusive problem. Under the inspiration of Prof. Willstätter many workers have striven for years in the National Research Institute, and thousands of pounds have been spent, on a novel type of investigation involving tons of leaf material. Their credit is not the less for this, that the results have not at once proved to be of economic importance; one more province of ignorance has been strenuously conquered and annexed to the empire of knowledge.—F. F. B. in *Nature*.

The Scientific Basis of Rationing

An ideal ration is one which provides the adult with sufficient potential energy to meet all the demands made by the organs of his body for transformation into the kinetic form, and enough building material to make good the wear-and-tear of essential cells; a complete ration for children and adolescents must also make provision for the requirements of growth. Three methods of determining the quantities needed to fulfill these conditions are available. The first is to follow as closely as possible the system of an engineer, viz., to study the efficiency of the human machine as a transformer of energy when measurable amounts of work are performed under determinate conditions. The second is to measure the total energy transformed by the body under various conditions, also determinate, although not necessarily permitting of an exact evalutation of the amount of mechanical work done. Lastly, when it is neither possible to measure directly the energy transformed nor to evaluate the work done, the composition of diets consumed by samples of men engaged in different occupations throws light upon the probable needs of different classes.

These methods have been enumerated in a descending order of importance so far as the accuracy of the information which, under favorable conditions, they might yield is concerned; so far as practicability is involved, under normal conditions of life, the order is reversed. We shall refer briefly to the data available under each heading.

(1) The only type of work respecting which numerous and exact measurements both of energy transformed and of external work done are available has been that carried out with a stationary bicycle, the wheels of which are rotated against a known resistance. The best series of experiments is due to Benedict and Cathcart,[1] whose results are concordant with those of Macdonald[2] and others. From these experiments it appears that, for any one person, the relation between H, the total energy transformed (measured in thermal units), and W, the external work done (also measured in thermal units), is adequately expressed by the equation $H = aW + b$, where a is a constant and b a variable parameter, varying with the speed of work performance. In the case of a professional cyclist, upon whom Benedict and Cathcart performed a large number of experiments, a was approximately equal to 3.3, while b increased from 2.4 to 5.2 as the rate at which the pedals were rotated increased from 68-72 to 108-112 revs. per min. When unpracticed persons used the ergometer the value of a increased, but the available data were not sufficient to permit of the parameters being determined with any accuracy.

From these results we may infer that (i) the incremental efficiency of muscular work may be as high as 30 per cent in favorable circumstances, and (ii) the total cost of work performed depends upon its rate. We can scarcely, however, venture to generalize the arithmetical results by using them to calculate the needs of those doing other kinds of work.

(2) This method was largely used by Zuntz and Schumburg[3] in their well-known study of the requirements of marching soldiers, and has also been employed by Amar[4] in investigating the energy transformations of industrial workers. Many physiologists, including Atwater and Benedict, Voit, Rubner, and Tigerstedt, have carefully determined the heat output of persons at rest, obtaining reasonably concordant results, so that the energy transformations of workers can be contrasted with those of sedentary persons.

From Amar's experiments it appears that a metal filer plying his tool at the rate of 70 strokes per minute (a skilled operative, aged thirty-eight years, weighing 74 kilograms) would transform or liberate 3,656 calories daily if he worked at the rate mentioned for eight hours, slept for eight hours, and "rested" the remaining eight hours. The figure just given is reached on the assumption that the heat output during sleep is 1 Calorie per kilogram of body-weight an hour; during non-working but waking hours, 1.25 Calories—assumptions in accord with the means of other experiments. Allowing a margin of 12 per cent to cover unavoidable waste in the preparation of food and non-assimilation of portions of the the ingredients consumed, this daily transformation is covered by a diet having an energy value of 4,155 Calories as purchased. Little significance attaches to an isolated series of observations, and it is to be hoped that the method will be more widely employed in that organized physiological research into industrial conditions which is an urgent need of the time.

(3) This process has been widely adopted, the largest individual collections of statistics being (a) those recently compiled and analyzed by the Welfare and Health Section of the Ministry of Munitions, and relating to more than 18,000 munition workers;[5] (b) the studies issued from the Nutrition Laboratory of the United States Department of Agriculture, which cover more than 13,000 persons, of whom, however, only a small minority were industrial workers;[6] (c) the Solvay Institute's analysis of the food consumption in more than 1,000 Belgian industrial families;[7] (d) English urban working-class and agricultural budgets analyzed by the Board of Trade some years ago.[8]

In the following table mean values computed from the above-mentioned material (omitting the American data, which may not be strictly comparabie with these describing European conditions) are collected:

Source of data	No. of observations	Grams of protein daily	Grams of fat daily	Grams of carbohydrate daily	Calories daily
English agricultural families	More than 100	90·9	92·4	570·3	3571
Urban industrial families, earnings 25s.–30s.	289	91·8	70·6	564·6	3348
Urban industrial families, earnings 30s.–35s.	416	99·0	82·4	587·6	3581 *
Belgian industrials, moderate and hard work	687	(83·4)	(98·3)	(524·3)	(3495) 3972
Belgian industrials, very hard work	372	(84·3)	(113·1)	(562·8)	(3772) 4286
English munition workers (1917)	18,000	115·7	141·3	408·4	3463

* The average for the whole 1944 families (wages ranging from less than 25s. to more than 40s.) is:—

Protein	Carbohydrate	Fat	Calories
98·8	593·2	83·7	3615

The figures in this table, excepting those for Belgium, refer to food as purchased. The Belgian investigators have expressed their results in terms of food absorbed by the digestive organs; the deduced averages are accordingly enclosed in brackets, not being directly comparable with the others. The unbracketed figure for Calories is that obtained on the assumption that a discount of 12 per cent should be allowed between purchased and assimilated values, and is (if the assumption be admitted) comparable with the remaining average energy values.

These statistics must be interpreted with caution. Two assumptions are made in computing nearly all averages of the kind, and a third is often involved also. The assumptions in question are (a) that published analytical results showing the composition of foodstuffs are generally applicable to the qualities used by the persons whose diets are under investigation; (b) that in families composed of persons of different sexes and ages the individual distribution of food among the members of the families can be expressed by the age and sex coefficients proposed by Atwater; (c) that published coefficients of wastage and proportional absorption are trustworthy. In addition to these special difficulties there are, of course, the usual pitfalls of statics (errors of sampling, randomness or otherwise of sampling, etc.).

From the evidence furnished by a short series of control experiments carried out by the Belgian inquirers, Slosse and Waxweiler, it seems likely that the American coefficient of reduction for sex, *i. e.*, putting the consumption of an adult woman as 80 per cent of that of an adult man, is not far from the truth; but, on the other hand, the American coefficients of consumption by children may be appreciably too small. The result is that, so far as reduction to "man values" is concerned, the English munition workers' mean is accurate, while the means of the other collections of data (which are reduced from family budgets comprising the nourishment of children as well as that of adults) may overestimate the *per caput* "man" consumption, perhaps even as much as 20 per cent. Regarding the discount to be allowed for waste in preparation and non-assimilation, much depends upon the constituents of the diet, and the figure of 12 per cent cannot be regarded as more than a very rough approximation.

Notwithstanding these limitations, the value of the data is considerable, and a study of them might induce some popular journalists and amateur food economists to moderate their strictures upon the extravagance of the English working classes which is alleged to have been fostered by the wartime rise in wages. The data do not suggest that the energy value of the diet consumed by so important a group of operatives as the munition workers is substantially greater than that received by persons of the same social and industrial class before the outbreak of hostilities. The distribution of energy between the three classes of foodstuffs has been different, an inevitable result of the potato famine and the appeals to eat less bread which characterized the period (spring and summer of 1917) during which the data were collected.

The general conclusion to be drawn from the statistics and the relatively few experiments available is that 3,500-3,800 Calories in food as purchased are by no means an overestimate of the nutritive requirements of an adult man engaged in moderately strenuous work. Recent work, indeed, confirms the view that Atwater's standard, so far as energy value is involved (3,500 Calories), is not an extravagant one.

The *British Medical Journal* in its issue of December 1st directed attention to the fact that the Food Controller's voluntary ration for men on medium work provided about 2,100 Calories, leaving a deficit of 1,400 Calories from the total of 3,500, which the evidence just set out shows to be a minimum requirement of workers in this class. Our contemporary concluded that a weekly consumption of 9½ oz. of fish and a daily consumption of one pint of milk were as much as could be hoped for from these so far unrationed articles, which leaves (cheese being notoriously scarce) a balance of nearly 950 Calories to be obtained from potatoes, involving a daily consumption of more than two pounds. These facts show the urgent necessity of carefully organizing the distribution of potatoes within the country and the obligation imposed upon these persons living near the centers of supply (for instance, in suburbs with available allotments) to make free use of potatoes, thus helping to increase the quantities of cereals available in the industrial districts to which bulky vegetables are not easily transported. The gravity of the situation imposes a further duty upon the readers of a scientific journal, who must inculcate upon their friends the elementary principles of bioenergetics. That the relation between muscular work and food is as close as that between the mileage of an automobile and its consumption of petrol is a truth still hidden from nine out of ten educated persons; ignorance of the facts has been the parent of many untrue charges.—From *Nature*.

[1] "Muscular Work: a Metabolic Study." (Washington, 1913.)

[2] Proc. Roy. Soc., B. 1917, vol. lxxxix., p. 394.

[3] "Studien zu einer Physiologie des Marsches." (Berlin, 1901.)

[4] "Le moteur humain" (Paris, 1914), pp. 527 *et. seq.*

[5] Summarized in Dr. Leonard Hill's "Memorandum on Workers' Food" (Health of Munition Workers Committee, No. 19, Cd. 8798).

[6] Contained in successive Bulletins of the U. S. A. Department of Agriculture.

[7] Slosse and Waxweiler, "Enquête sur le Régime alimentaire de 1065 ouvriers Belges." (Brussels, 1910.)

[8] Board of Trade, 1903, Cd. 1761, p. 210; 1913, Cd. 6955, p. 300.

Oil from Oil Shales

The question is being asked daily what this country is going to do when our petroleum resources are exhausted. We have as yet untouched our great reserves of shales that contain oil. These shales are found in many parts of the United States, and tremendous reserves are known in Colorado, Utah, and Wyoming. There is only one country in the world where oil shales are being utilized for the production of oil—Scotland, where little petroleum occurs and where the demand for petroleum is great. Some of our shales are much richer in oil than are the Scotch shales, and are conservatively estimated to contain many times the amount of oil that has been or will have been produced from all the porous formations in this country.

To obtain the oil from oil shale it is necessary to heat the shale in great retorts. The oil is the result of destructive distillation and is driven off in the form of vapor and is later condensed by cooling. As stated above, this process has never been used in this country because of the lack of necessity, for our oil reserves are great, and it would not be commercially economical to invest money in retorts for distilling oil from shale oil that would have to compete with the crude oil obtained by other methods. But this condition will not last forever. In fact, it is thought that it will be only a very short time until the oil-shale industry will be one of magnitude.—*Yearbook of the U. S. Bureau of Mines, 1916.*

Electrolytic Recovery of Tin

Speaking recently to the Salvage Club, Mr. David Currie, Director-General of National Salvage, said the electrolytical recovery of tin from stannate solutions is, perhaps, the most economical one to adopt at the present time, especially owing to the simplicity of the plant required, and also in view of the fact that the materials and solutions required can be readily obtained. In this process the scrap tin, after cleansing, to remove grease, etc., is charged into suitable containers and immersed in a hot caustic soda solution. Cathodes consisting of iron or copper plates are arranged in the vicinity of the containers, on which the tin is deposited in spongy form, which is removed from time to time and reduced to metallic tin in, special furnace. A plant of this type, requiring about 20 kilowatts working continuously, is found capable of dealing with about 15 tons of scrap per week and recovering about 3 cwt. of tin of 98 per cent purity.—*The Engineer.*

10,000 Double Van Sion Narcissus on a bulb farm

Scene in a 10-acre patch of Narcissus at Eureka, Cal.

Bulb Growing in the United States

A California Farm that Rivals the Best in Holland

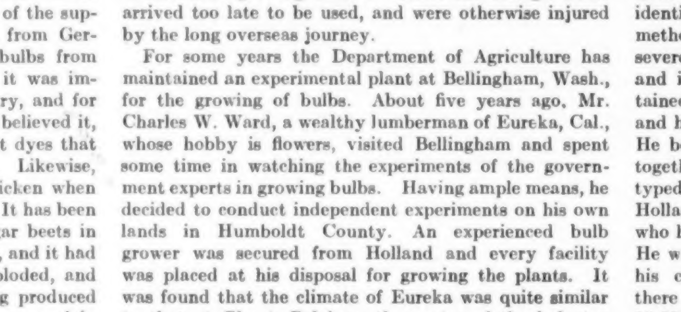
By Arthur H. Dahl

THE world war is not only changing the political relations of all nations, but it is creating tremendous economic changes in the business relations of the various countries. Before the war this country was almost dependent upon foreign countries for certain of the supplies which it needed. Dyes were secured from Germany, sugar-beet seed from Austria, and bulbs from Holland and Belgium. We were told that it was impossible to make suitable dyes in this country, and for a year or two after the war began we almost believed it, but today American chemists are turning out dyes that are fully as good as those made in Germany. Likewise, our beet growers in the West were panic-stricken when imports of Austrian beet-seed were shut off. It has been said that while we could grow the finest sugar beets in world, our climate would not mature the seed, and it had to be imported. That fallacy has been exploded, and today American-grown sugar beets are being produced from American-grown seed, and the crops are equal in quality and quantity to those of old.

Another fallacy that has been exploded by American ingenuity and American perseverence is in the matter of bulb raising. For centuries the bulb industry of the world has been restricted to a few districts in Holland and Belgium and the annual importations to the United States averaged over $7,000,000. If we wanted the beautiful tulips or azaleas to bloom in our gardens we were compelled to buy the bulbs from abroad, paying high prices for them. The bulb business was virtually a monopoly, and efforts to experiment in other countries were discouraged by those in control. The history of bulb growing in Holland is replete with the most spectacular experiences, and in many ways resembled the periods of "frenzied-finance" which have occurred from time to time in the United States. In the middle of the seventeenth century bulb culture had reached such a craze that the wildest speculation prevailed, and men and women in all stations of life gambled in them, and prices for individual bulbs reached extravagant figures, one famous species, the Semper Augustus, selling for $5,000 each. In the midst of this boom, the large growers of bulbs decided that this speculative fever was injurious to the busines, and by concerted action they placed upon the market large quantities of mature bulbs, thus breaking the market. Thousands of fortunes and savings of a life time were wiped out in the slump, but from that time on the tulip business of Holland was conducted on a strictly commercial basis. Since the war it is said that over half of the bulb area of Holland has been diverted to other uses, and practically all of the Belgium bulb farms have been destroyed. The industry has also been greatly restricted in France.

Today, in Humboldt County, Cal., near Eureka, are grown large quantities of bulbs that are pronounced by experts to be equal in every respect to those imported from Holland. These bulbs ripen fully a month earlier than the Holland crop, and it is therefore possible to deliver them to the American buyer in ample time to use in the next growing season. Often the foreign bulbs arrived too late to be used, and were otherwise injured by the long overseas journey.

For some years the Department of Agriculture has maintained an experimental plant at Bellingham, Wash., for the growing of bulbs. About five years ago, Mr. Charles W. Ward, a wealthy lumberman of Eureka, Cal., whose hobby is flowers, visited Bellingham and spent some time in watching the experiments of the government experts in growing bulbs. Having ample means, he decided to conduct independent experiments on his own lands in Humboldt County. An experienced bulb grower was secured from Holland and every facility was placed at his disposal for growing the plants. It was found that the climate of Eureka was quite similar to that at Ghent, Belgium, the center of the industry in that country, any differences being in favor of Eureka.



A California nursery where 5,000 Azalea Pink Pearls are grown at once

For instance, dangerous frosts seldom occur in California, while at Ghent they are not uncommon, and as the growing fields at Eureka lie close to the Pacific and are visited by nightly fogs heavily laden with mositure, the growth of the plant was fostered. Eureka-grown azaleas ripen their flower buds six weeks in advance of the Belgian-grown plants.

One of the conditions for the successful propagation of flower bulbs is that they must be grown in pure leaf-mold. That used in Europe is a mixture of oak leaves and spruce or pine needles. Exhaustive experiments conducted on the Ward planatation demonstrated that redwood leaf-mold was superior to any other combination, and as large forests of the giant redwoods were near at hand, an abundant supply of this material was available. Where mixtures of different kinds of leaves were tried, based on those used abroad, it was found that the greater the proportion of redwood needles the better the growth, and by the use of pure redwood needles it has been possible to secure a plant as large at two years of age as one three years old grown in Belgium.

The Hollander secured to conduct the Ward experiments was deeply imbued with the orthodox methods used in Holland, and the garden beds were laid out identically as they were abroad and the same cultural methods used. Although the first winter was unusually severe, the plants came through in fairly good condition and in the spring a great showing of flowers was obtained. But the owner was not satisfied with results, and had some ideas of his own which he wanted to try. He believed that the plants had been grown too close together, but as all suggestions were met by the stereotyped reply from the Hollander, "We don't do that in Holland," a change was made and another Hollander, who had been twelve years in this country, was secured. He was less prone to follow the beaten path, and under his charge great improvements were made. Today there are 100 acres of the Ward ranch planted to over 10,000,000 bulbs of numerous varieties, and the American product has been sold to florists and gardeners all over the country, meeting with uniform success and commendation.

The method of planting as now practiced at Eureka consists in having the plants grow in wide beds, instead of narrow ones, as abroad. The rows are spaced two feet apart, to admit of machine cultivation, and the bulbs, spaced three inches apart in the rows, are planted in deep drills opened with a small hand plow and covered with a double plow with the moldboards turned inwards. Modern machinery, including tractors, is used wherever possible, thus keeping down the cost of labor.

Bulbs, like onions, need an abundant supply of nitrogen and the soil in which they are raised must be cultivated to a considerable depth. At Eureka the soil along the river bottoms is composed of deep, heavy, fertile silt. The benches above the river bottoms and the slopes fronting the ocean are composed of a sandy loam, heavily enriched for centuries with an accumulation of vast amounts of leaf-mold deposited from the rank growths of forests and ferns.

The top soil, black, like the soils of the Holland bulb districts, ranges from eighteen inches to four and five feet in depth. The subsoil ranges from a hardpan in the lowest spots to a clear, porous sand of unknown depth. The annual rainfall is about 46 inches, and it occurs between the middle of December and the first of June. As the heavy rains of the winter are stored in the subsoil, they are readily drawn to the surface by capillary attraction to feed the growing plants. In the summer, the prevalence of wet fogs adds materially to the moisture furnished the growing plants.

As soon as the blooms are snipped off the actual regrowth of the bulb begins. Mother tulips split up into smaller bulbs, called splits, each bulb giving from three to six or seven new bulbs, according to variety. Narcissi break forth into double and treble-nosed bulbs

and if Darwin and late tulips are left in the same position three years, ten to thirty new bulbs are formed, sixty per cent of which will make flowering bulbs the first year after replanting.

The period of ripening of the different varieties extends until the latter part of April or the first of May, and as rains occur at this time there is ample moisture in the ground to support a vigorous growth of the rapidly enlarging bulbs. Digging the bulbs commences the last week in May and extends until the last of July. Planting commences about the first of September.

One of the plants which has been successfully grown by Mr. Ward is the azalea, of Belgium, over 1,000,000 bulbs of which were annually imported into this country prior to the war. The bulbs produced in California have been tried out all over the country and florists report that they are entirely satisfactory. The fact that under normal conditions of transportation in the United States, all Pacific Coast azaleas can be in the hands of the forcers not later than October 10th, and also that the plants will not be exposed to injury while in transit for long distances, renders success certain in blooming American-grown plants.

More than half a million dollars have been spent by Mr. Ward in his propagating gardens at Eureka, and the plant is one of the most elaborate and well-laid out to be found in the world. Every problem has been worked out scientifically, and a force of engineers and expert gardeners is maintained to carry out improvements. Ample reservoirs have been provided to insure an adequate supply of pure water, some of the fields have been equipped with a patented overhead irrigation system, and thousands of tons of redwood leaf-mold are gathered and prepared to fertilize the growing areas. Although the plant has now become commercially successful, it was started with no definite idea of making money but with a view of determining whether or not it was possible to grow bulbs as successfully as they do abroad. That we can do this in America has been fully demonstrated by the work of Mr. Ward, and in the years to come the bulb buyers of the world will be coming to California for their supply, and instead of spending $7,000,000 a year for imported bulbs, we can keep that money at home, and perhaps create a credit balance on the other side of the ledger.

A Portable Street Flusher

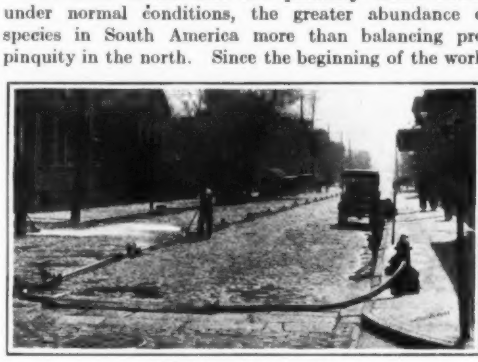
The accompanying illustration shows a novel portable pipe line street flusher, developed at Buffalo, N. Y. Unlike the wagon or motor flushers, this machine does not hastily skim over the pavement and simply drive the dirt in the direction of the curbs. The pivotally mounted discharge nozzle, which can quickly and easily be turned in a complete circle if necessary, enables the operator to direct the stream so as to clean the entire pavement from curb to curb in a thorough and sanitary manner.

It is pointed out that the stream from one nozzle cleans to a line ahead of the next nozzle and the valve is then closed. In this way the operator works along the entire line, always cleaning down grade. One of the end units in each set has two swivel joints and combination nozzles, giving the advantage of cleaning a distance equal to another unit. It takes from five to seven minutes to thoroughly clean a street the full width a distance of 240 feet.

It is claimed that no water is wasted in cleaning any pavement. The operator can shut off the water at will with the valve wrench which he carries. When a given distance is thoroughly cleaned and while the operator is walking to the next valve the water is shut off. The low set pivotally mounted discharge nozzle makes it impossible to damage the worst kind of pavements. Sand and grouting is never washed from between paving stones with this flusher.

It will be seen that the operator has no weight to carry except a small valve wrench. The nozzles are worked with a long handle. A simple turn gives any direction desired. Two men can move the whole line intact along the street from one hydrant to another. The intermediate flexible hose connections allow the entire line to be moved intact around street corners.

For transporting purposes, the units are uncoupled and loaded one on top of the other on a wagon or lorry. Usually the different sets are distributed to the different centers in the morning and called for at the end of the day. The streets are never blocked with this system as photo shows. It is held that the maintenance cost of this device is slight and there are no complicated parts in the construction and no delicate parts to get out of order, and it is maintained that the cost of street flushing has been reduced 75 per cent with this system.



Washing the streets

Where Our Birds Come From*

By Lee S. Crandall

Birds are so widely dispersed over the surface of the earth that barren indeed is the spot without avian life. The great gift of flight has carried them to the farthest corners of the globe. Perfect plasticity of form and habit have allowed adaptation to a multitude of changing conditions. From Arctic to Antarctic, birds have fitted themselves to every conceivable type of environment. Every land, however inhospitable, has its share of the 20,000 forms of feathered life.

The study of the geographical distribution of life on the earth has led to the recognition of well defined areas, distinguished by the character of their fauna. Six main life zones, corresponding in general to the continental bodies, have been separated. Each has numerous subdivisions but for our purpose, the six will suffice.

Briefly, North America forms the Nearctic Region; southern Mexico, the West Indies and South America, the Neotropical. Europe, northern Africa are included in the Palaearctic Region, while southern Asia and the neighboring islands are known as the Oriental. Arabia and Africa south of the tropic of Cancer are assigned to the Ethiopian Region; Australia, New Guinea and the East Indies to the Australian.

The sequence of these regions in point of numbers of species represented in the collections of the New York Zoological Society is interesting. It depends in some degree on the number of forms indigenous to the zone under consideration, but chiefly on their accessibility. The 802 species of birds now living in the Zoological Park are grouped as follows: Neotropical, 237; Nearctic, 162; Australian, 118; Ethiopian, 84; Palaearctic, 81; Oriental, 78. Forty-two species either are cosmopolitan or range extensively through more than one region, so that they may not fairly be assigned to one.

The order of the first two probably would obtain under normal conditions, the greater abundance of species in South America more than balancing propinquity in the north. Since the beginning of the world war Europe, Africa and the Orient have been almost entirely cut off, and most of the species which still represent them have been in our possession three years or more. The position of the Australian area is abnormally high, the same factors which have interrupted our supply in some cases having had the reverse effect in this. The trade in Australian birds has been diverted from Europe to America and there is no doubt that New York now has the finest collection of Australian fauna ever gathered by a single institution outside that country.

Every extreme of habitat has contributed its mite. The ice fields of the far north, the dripping jungles of the tropics, the giant peaks and the seas of many lands, have been skillfully searched.

The gathering of such a company is a herculean task. A group of tiny finches, a brilliant bird of paradise, a flock of penguins, each could tell a tale of adventure and romance that would enthrall the listener. One may get a hint of this from the descriptive labels on the cages. New Caledonia, Formosa, Pegu and Patagonia are good material for castles in Spain. But for full realization of the meaning of these names, one must visit the wharves and docks and the shops of the great importers, where come the men to whom New Calendonia and Formosa are not mere words on a label.

That brilliant if diminutive Gouldian finch, gravely wheezing his ludicrous song, represents the climax of the effort of a succession of human minds and hands. Some Australian bushman has spent weeks in the lonely scrub of the northwest, keeping vigil at the only water hole for miles about. At last, a single pull of the netrope has enmeshed dozens of gaudy mites. Then the gruelling trip back to the outposts of civilization, where the catch is turned over to the local dealer. After a long trip at sea, in charge of the agent of an American or European trader, comes the arrival at New York, San Francisco or "somewhere in Europe." Here the birds are resorted and reshipped to the many retailers who distribute them among the final owners.

In India much the same system prevails, except that the trapping is done by natives. In the neighborhood of Bombay and Calcutta, professional bird-catchers ply their trade. The great markets of these cities have many bird stalls, each well supplied with potential songsters. Farther north, collecting is more casual, and less skillfully done, so that few birds reach us from that region.

The course followed in Africa is a middle one. Here the collector is usually in quest of the mammals which abound, and to him birds are of small consequence. Such as he does get are obtained quite by chance from natives, as the caravans are passing. There are, however, a few dealers who gather birds from the native catchers and dispose of them to traveling agents.

The South American method is quite different. Here are no proper trappers, skilled in their art. Although the Neotropical Region boasts of far more species of birds than any other, its possibilities are almost entirely undeveloped. In the public markets of most of the larger cities, birds of a few common kinds are generally to be seen. Occasionally one finds a man, usually a Portuguese, who conducts a sort of zoological clearing station. But for his wares he depends on more or less nomadic Indians, who bring their hand-reared pets from the interior. The only birds commonly trapped are the smaller finches and tanagers, which are caught in some numbers, as occasion demands, by small boys.

This region has been exploited chiefly by American dealers whose stock in trade consists of parrots and monkeys. Few uncommon or delicate birds reach us from this source. By means of our own expeditions and the permanently established Tropical Research Station, we have done much to overcome these obstacles. The latter, especially, has brought us many rarities. But not until the dealers who control the market have acquired more of both skill and initiative, will the zoological treasures of the great southern continent fully be opened to us.

*New York *Zoological Society Bulletin*.

Paint for Iron

An investigation to determine the broad principles governing the successful application of paint to iron was described by Dr. J. Newton Friend before the Iron and Steel Institute. The method of experiment he adopted was to expose steel plates, coated with various paint mixtures, to the weather for periods varying from five months to 2½ years, and then ascertain the loss in weight due to corrosion.

He concludes that the addition of pigment to oil increases the efficiency of the latter as a protective paint up to a certain maximum, after which the further addition of pigment causes deterioration. The best results are obtained from paints possessing as high a percentage of good oil as is compatible with good body and other working properties. The primary cause of crinkling is that linseed oil on setting expands by some 3.3 per cent. Further oxidation causes a decrease in volume, which in time leads to cracking. Linoxyn is permeable to moisture, and the permeability is reduced by heating in the absence of air, the oil increasing in density, viscosity, and molecular weight. Polymerized linseed oil affords a better protection than raw oil when used as a paint vehicle.

The pigment toughens the film and renders it less permeable to water, vapor and oxygen. It also reduces the expansion of the oil on setting, and thus minimizes the tendency to crinkle. Other things being equal, the most permanent paints are those containing black or red pigments, since these absorb the shorter rays of light and prevent them from hastening the destructive oxidation of the linoxyn by the air. Finer pigments afford more efficient protection than coarse ones, since they are more thoroughly in contact with the oil.

A thick coat of paint protects the metal under it more effectively than a thin coat, provided it is not so thick that running or crinkling takes place. The best results are obtained by multiple coats; two thin coats are better than one thick one of equal weight.

The cheapest method, and the one best calculated to prolong the life of the metal, is to paint iron structures while their scale is still on, loosely adherent flakes and rust having been removed. The coat of paint will last rather longer than it would if applied to a pickled or sand-blasted surface, and the labor and time required to remove the scale are saved. When the coat of paint is worn out it should be scraped off, together with any loosened scale and rust, and the structure repainted in the ordinary way. While the experiments with rusty plates are not conclusive they suggest that the rust need not be removed before painting so carefully as is usually thought necessary.—Engineering Supplement of the *London Times*.

Fish Isinglass and Fish Glue*

Sources and Methods of Manufacture

By George F. White

COLLAGEN, the mother substance of gelatin, is an albuminoid which occurs to a large extent in vertebrates and also in the flesh of cephalopods. It is the chief constituent of the white fibrils of connective tissue and is also found in bones, cartilages, ligaments, fish scales, etc. Collagens of different origins are not of identical composition; however, all show the characteristic albuminoid property of being insoluble in water and the ordinary protein solvents.

The most interesting and commercially important property of collagen is its power to be converted into gelatin by heating with water alone or in the presence of dilute acids. On the other hand, if gelatin is heated to 130° C. it is transformed back into collagen, so that there is a very intimate relation between the two substances. For practical purposes we may consider gelatin to be collagen which has been converted into a soluble form by combination with water. (Other changes have been noted, such as the evolution of ammonia, when collagen is treated with water.)

Collagens are to a certain extent differentiated by the ease with which they are converted into gelatin. Thus the collagenous cartilage of the trachea is transformed at 100° C. into gelatin, whereas ear cartilage requires a temperature of 110°; the collegan of air bladders forms gelatin at room temperatures. In general, the formation of gelatin takes place most readily with fishes and amphibia, more slowly with birds, and very slowly with old animals. The presence of salts, for example, of sodium chloride in a concentration of 10 per cent retards the transformation.

Gelatin (French *gélatine*, Latin *gelata*, that which is congealed) is a colorless, amorphous substance which is transparent when in thin sheets. It does not dissolve in cold water, but swells in this medium. If treated with warm water, it dissoves to a sticky liquid which, if sufficiently concentrated, sets to a jelly on cooling. If gelatin is boiled with water for several hours (or simply digested with water for two days at a temperature of 37° C.), it is converted into a nongelatinizing form; further boiling transforms it into proteoses, peptones, and finally into acids, among which glycocoll is present in a characteristically large amount. This fact should be borne in mind in a study of the commercial uses of gelatin, since prolonged boiling, especially in the presence of acids, changes it chemically and physically (the gelatinizing) and correspondingly the adhesive power is destroyed.

As a food, gelatin has little nutritive value, and should not be substituted for other proteins of the normal diet since not all of its nitrogen is in a form which can be utilized by the organism.

Gelatin, obtained as described above, should not be confused with the products derived from algæ and seaweeds of different varieties, especially those of the East Indies, China, and Japan. Thus the gelatinizing substances obtained from bird's nests, prized as delicacy by the Chinese, and Bengal isinglass, or agar, yield carbohydrates in large amount and have no relation chemically to true gelatin.

While the principal supply of gelatin is today obtained from the refuse of animal bones, hides, and hoofs in the slaughter and packing houses, the peculiar properties of the gelatin derived from fish sounds, called isinglass in the trade, makes this product of considerable commercial importance.

The fish sound (air bladder, or swim bladder) is a hollow sac, containing gas (oxygen, carbon dioxide, and nitrogen), situated in the abdominal cavity below the vertebral column. Its principal function is probably mechanical. Since it is compressible, it serves to regulate the specific gravity of the fish, enabling the latter to rise and sink or to maintain its position at a certain water level. In a few fishes it may take on the functions of the lung of higher vertebrates and may be considered to be the homolog of that organ.

The size of the air bladder varies to a great extent, being very small in some species, whereas in the sturgeon, hake, catfish, and carp it is highly developed. In some fishes the sound is practically loose in the abdominal cavity, while in others it clings closely to the backbone, the intestines, and the abdominal wall. The sound is made up of several tunics of which the inner layer is thin, often with a silvery luster, containing crystalline substances, sometimes covered with a pavement epithelium. The adjacent layer is thick and with a fibrous structure; it is the collagen contained in this layer which is the source of commercial isinglass.

Isinglass (probably a corruption of the Dutch huisenblas, German hausenblase, literally sturgeon's bladder) has for centuries been manufactured and exported from Russia. Several varieties of the sturgeon (*Acipenser huso* or beluga, *A. ruthenus* or sterlet, *A. sturio* or common sturgeon, *A. stellatus* or starred sturgeon), of catfish (*Silurus glanis*), and of carp (*Cyprinus carpio*), flourishing in the Volga and other rivers, in the Caspian and Black Seas, and in the Arctic Ocean, yield the well-known Russian isinglass.

Other sources of supply than Russia are Brazil, Venezuela, the East and West Indies, Penang, Bombay, Manila, Nova Scotia, Newfoundland, and the United States. Russian isinglass is known in commerce as staple isinglass, and is sold as long and short staple, according to size.

Leaf isinglass (Astrakhan leaf, Saliansky leaf, Samovy leaf, etc.) is prepared by soaking the sounds in warm water, whereby dirt and mucous membrane are removed. The sounds are then opened and dried by exposing the inner membrane to the air; the dried sounds may be further treated by pounding and rubbing until the outer membrane is detached and separated from the purer, inner layer. Book isinglass is prepared in a similar manner, but the sounds are folded and covered with a damp cloth. Trimmings from the leaf or book are pressed into cakes or tablets or rolled into ribbons and sold as lower-grade isinglass. The trimmings from the sounds and other parts of the fish are often boiled in water until the gelatin dissolves and the filtered solution is evaporated to dryness. There is also cake isinglass, so called from its shape, although sometimes it is made in a globular form.

Long staple and book isinglass are the best varieties, a 2 per cent solution in hot water setting to a jelly when cold, and yielding only 0.05 per cent insoluble matter. Cake isinglass is dark colored and of unpleasant odor. A low grade of Russian isinglass, also sold under the above names is manufactured from the peritoneum and intestines of the fish.

Iceland produces an excellent grade of isinglass, which is obtained from cod and ling sounds, only a little inferior to the Russian product. Venezuela and Brazil export tongue sounds and lump and pipe isinglass which are obtained from Siluridæ and other less definitely characterized fish. Tongue sounds are oblong, tapering, and pointed at one end, of firm consistency, but otherwise poorer than the Russian product. From Penang and Bombay are exported tongue sounds and also purse sounds, so-called from their shapes and their fringed edges.

The production of fish sounds in this country has fallen off in the last few years, and the demand being good the value of the imports has increased. Norwegian cod sounds have been imported at different times.

North American isinglass is derived from the sounds of hake, cod, and squeteague, hake sounds being the principal source. A few years ago over 100 tons of hake sounds were obtained annually on the New England coast line, but the production has fallen off considerably in recent years. Large amounts are imported from Canada and Newfoundland.

Hake sounds from fish caught in deep waters off the coast of Nova Scotia are large and of good quality. One ton of these fish yields 300 to 500 sounds, weighing from 40 to 50 pounds. Hake sounds from shallow waters are smaller and of a lower grade; 1 ton yields about 600 sounds, weighing approximately, 30 pounds. Hake sounds are easily detached from the backbone in dressing the fish on the fishing vessels, and then they are salted in barrels. Before salting they may be scraped and washed but these operations are usually omitted without much injury to the character of the isinglass manufactured from them. When delivered on shore, the sounds are slit open and thoroughly washed and the black outer membrane is scraped off. They are then dried in the air with precautions to prevent access to moisture, since they readily putrefy. The average hake sound yields about 85 per cent gelatin.

Cod sounds are smaller than those of hake and of poorer quality. One ton of fish yields 15 to 20 pounds of sounds. As they are more firmly attached to the backbone than are hake sounds, they are cut off with part of the backbone, scraped, washed, and salted. They are then washed and dried on shore. Cod sounds yield only about 50 per cent gelatin, so that they are much less valuable than hake sounds.

Sounds of the squeteague, which fish occurs along the Atlantic seaboard, are at present only little utilized. One ton of fish yields about 20 pounds of sounds, which are of as good quality as cod sounds. Over 30 years ago about 15 tons of dried sounds of the squeteague were sold annually, but the production since that time has dwindled to a negligible amount.

The sounds of many fresh and salt water fishes are at present unutilized.

The sound of the tilefish (*Lopholatilus chamæleonticeps*) was tested by the writer to determine the character of its principal constituent and its possible utility. The presence of collagen (rough experiments showed that over 90 per cent of the nitrogenous matter of the swim bladder is collagen), and the fact that it may be readily converted into gelatin allow the sound of the tilefish to be put to the same use as the sounds of the sturgeon, hake, and other fishes.

MANUFACTURE AND USE OF ISINGLASS

Isinglass is manufactured by an exceedingly simple process. The industry was initiated in the United States in 1821, at Rockport, Mass., cleaned hake sounds being pressed into plates. In 1834 the procedure was somewhat improved, and the cleaned sounds, softened to the desired consistency by soaking in water, were converted into ribbon isinglass by being passed between solid rollers. The ribbons were then dried. In 1848 the solid rollers were replaced by hollow iron rollers, through which cold water could flow, and thus prevent the ribbons from softening and sticking to the iron, as they are apt to do, especially in warm weather. In 1873 a scraper was placed against the rollers to remove all isinglass adhering to them. The ribbons were made to the desired thickness by adjustment of the space between the rollers.

The manufacture of isinglass is best carried on through the cooler months on account of the softening and putrefying effect of a slight rise in temperature. Four to six hours may be required for the gelatin to absorb enough water to be sufficiently pliable to handle. The sounds may now be run into a cutting machine provided with a roller and a set of knives which chop the sounds into small pieces. This material is then further mixed and macerated between a set of iron rollers, from which it passes to so-called sheeting rollers. These are the hollow iron rollers, cooled by water and provided with a scraper, as mentioned above. The gelatin is converted into sheets one-eighth to one-fourth inch thick, 6 to 8 inches, wide and of variable length. These sheets are finally passed through ribbon rollers until the ribbons produced are one-sixty-fourth of an inch thick; the width is the same as that of the sheets. The ribbons are dried in a few hours by being suspended in moderately warm, light rooms; they are then rolled on wooden spools into coils weighing less than a pound each. About 20 per cent of the weight of the original sounds is lost during their conversion into isinglass.

A product called transparent or refined isinglass is manufactured by dissolving New England isinglass in hot water and spreading the solution to dry on oiled cloth. Very thin, transparent sheets are thus produced, and these yield an excellent grade of glue, but retain a rather pronounced fishy odor.

When the best grades of isinglass are treated with hot water, they swell uniformly, produce an opalescent jelly, and finally entirely dissolve. Isinglass is insoluble in alcohol, but readily soluble in most dilute acids and alkalies. When ignited isinglass should yield no more than 0.9 per cent ash, whereas poorer grades of fish glue, or gelatin, yield from 1.5 to 4 per cent ash.

Isinglass has been adulterated by rolling a layer of gelatin between two layers of isinglass. Such adulteration may be detected by treating with water and observing the nature of the colloidal solution under the microscope. Isinglass retains its characteristic fibrous structure which is not present in a gelatin solution; the gelatin becomes more transparent than before, the shreds being disintegrated. Both of these effects would be observed in the adulterated article.

The use of isinglass for edible purposes has become practically obsolete since the manufacture of gelatin on a large scale has become a function of the slaughter and packing houses. It was formerly utilized to stiffen jellies and jams and in the manufacture of confectionery, but has no peculiar medicinal properties. Some fish sounds have been esteemed as an article of food; thus it is said that fried cod sounds have a flavor resembling that of oysters similarly cooked.

Isinglass has long been used as a clarifying agent for beverages such as cider, wines, and malt liquors. The

*From Bureau of Fisheries, Document No. 852.

peculiar clarifying action is purely mechanical, those substances causing turbidity becoming entangled in the slowly sinking network of gelatinous material. This property is not possessed to the same degree by gelatin prepared from animal bones, hoofs, or hides, and such gelatin is far less efficient as a clarifier. English brewers of malt liquors prefer the Penang product, while Scottish brewers employ Russian leaf isinglass. English cider manufacturers generally use Russian long staple. American brewers formerly considered Russian isinglass as superior to other kinds, but later adopted the use of the ribbon isinglass made from hake sounds in this country.

White wines are usually clarified by isinglass. The isinglass is allowed to swell in water and then in wine until it is practically transparent. It is thoroughly beaten with more wine, a little tartaric acid being eventually added; after filtering through linen it is stirred into the wine. One ounce of isinglass will usually clarify 200 to 500 gallons of wine in 8 to 10 days.

In the storage of beer after the primary fermentation all suspended particles do not settle in the stock tanks. This is true of starch granules, bacteria, some of the protein matter, etc. From storage the beer is run into chip casks where it is carbonated by charging with carbon dioxide directly or by the addition of young beer, and at the same time clarified or fined. This latter process is carried out by the addition of chips or of isinglass, or by filtration. When isinglass is employed it is treated with sour beer, acetic, or other weak acid whereby it is not actually dissolved, but is "cut" by the acid. Finings thus prepared have an excellent clarifying action. One pound of isinglass will fine 100 to 500 barrels of beer.

Isinglass is the basis of some of the best adhesives. Although formerly used for postage stamps, envelopes, and gummed paper, the dextrins prepared from starch have largely taken its place. Mixed with two parts of alcohol a "diamond" cement is obtained, the cooled solution forming a white, opaque, hard solid. Dissolved in acetic acid another powerful cement is obtained, especially useful in repairing glass, pottery, and similar articles. Various modifications of these cements are prepared, particularly by the addition of some adhesive gum which will render the cement insoluble in water. Following is the formula for one of these: 10 grams isinglass, 5 grams gum ammoniac, 5 grams mastic, 80 grams alcohol. The isinglass and gums are dissolved separately in the alcohol and then heated together over boiling water. The excellent properties of isinglass as a glue may be illustrated by the fact that leather belts for machinery are repaired by the use of this agent. (In the trade it is often called Russian fish glue.)

Court plaster is made with isinglass as the adhesive. The proportions used are 10 grams isinglass, 40 grams alcohol, 1 gram glycerin, and water and tincture of benzoin in sufficient amount. The isinglass is dissolved in enough water to make the total weigh 120 grams. One-half of this solution is spread in successive layers, with the aid of a brush, on taffeta stretched on frames; each layer is allowed to dry before the next is applied. The second half of the isinglass solution is mixed with the alcohol and glycerin, and is applied to the cloth in a similar manner. The reverse side of the taffeta is covered with a layer of tincture of benzoin and allowed to dry. The above quantities are sufficient to cover a piece of taffeta 38 centimeters square.

Mixed with a gum, isinglass has been used as a size for textile goods, imparting a luster and stiffness to linens and silks. Combined with water, Spanish liquorice, and finely divided carbon, India ink may be made. A patent for waterproofing fabrics has been obtained by Van Winkle and Todd (English patent 20690, 1890), who recommend a combination of isinglass and pyroxylin dissolved in acetic acid; experience has shown that a bichromate must be added to the mixture or the isinglass rendered insoluble by formaldehyde for the mixture to be successfully used. Isinglass has in past years been used to adulterate milk, the addition of a small amount adding considerably to the body.

FISH GLUE

Glue is gelatin contaminated usually with various decomposition products such as gelatoses, peptones, and organic acids. The purer the gelatin the better glue it yields, so that a good glue should be as free as possible from other proteins, from hydrolytic splitting products, and from ash. Fish glue is usually made up into liquid glue, for which there is a reasonably large demand. The manufacture of mucilage and pastes of various sorts from the dextrins obtained from starch has largely limited the demand for fish glue so that enterprises based solely on this product have not been very profitable.

In New England fish glue is made from cod heads, skins and bones, haddock residues, and all fish offal containing little or no oil, as this constituent is fatal to the production of a good glue. The refuse from salting factories forms a very large part of the source of supply, as salt codfish is prepared in considerable quantities in this region. The refuse from sturgeon and the skins and scales of menhaden and herring have been used. Green and Tower[1] have shown that 1 ton of menhaden yields 20 pounds of dry scales from which 10½ pounds of pure gelatin (containing 16 per cent moisture) may be obtained. In this connection it may be noted that the adhesive qualities of the "stick" obtained by the present methods of concentrating the waste liquors of the menhaden industry are due to the large percentage of gelatin present; this material as now manufactured has use only in the fertilizer industry, as it contains too much salt, oil, and foreign protein substance to be serviceable for glue. Many other fish residues are now unutilized; such is the case of the mullet of the southern waters, which yields an excellent quality of glue.

In the last few years whale blubber has been utilized for the production of glue. According to the German patent 131315, the blubber is chopped up, freed from most of the fat by pressing in the cold, and the remainder of the fatty matter is extracted by some solvent, as benzene. By this method all the fat is recovered and a fat-free dry residue consisting of tissue containing the gelatin is obtained, and this may be readily converted into glue.

Attempts to produce glue from the grayfish (*Squalus acanthia*) have not been successful on account on the large amount of oil and water in the fish, the difficulties attended with the extraction of the oil, and the presence of dark pigments in the skin which discolor the extracts. It is also probable that the skeleton contains only a small amount (if any) of collagen or glue-forming substance. The flesh of the smooth grayfish (*Mustelus canis*) contains gelatin-forming material and presents possibilities as a source of glue.

MANUFACTURE AND USE OF FISH GLUE

In the manufacture of fish glue the fish wastes are first washed thoroughly with cold water to remove dirt and blood from the fresh fish and salt from the salted fish. The washed material is allowed to drain, the washings being discarded, and then is subjected to the action of hot water or steam.

In the older methods of preparing glue the crude material was treated with water and the mixture boiled in open glue kettles for several hours until the collagen had all been converted into gelatin which dissolved in hot water. This method yields a fairly good glue if the raw materials are clean and fresh, but because of the lengthy time required for complete extraction the liquor obtained is usually dark colored and contains in solution many other protein substances than gelatin. Glue thus prepared is often a poor adhesive and is malodorous.

Newer methods of fish-glue manufacture involve heating the stock with steam under pressure in an autoclave so that the extraction proceeds rapidly and there is less time for decomposition of the fish protein to occur. In some plants the stock is placed in tall iron cylinders, steam-jacketed, and heated for several hours until the whole mass is thoroughly digested. By a better method, the stock is placed within the inner, perforated section of a double boiler. Steam enters the inner vessel from the outer, and the whole is heated under pressure. The glue liquor filters out of the inner vessel and may be drawn off from the outer jacket continuously. Sometimes an alternate action of steam and cold water on the stock is brought into play, and this process repeated until the extract is too dilute to be profitably worked up into glue.

The digested fish wastes may be filter pressed and the residue dried. The resulting product, containing 45 to 55 per cent protein matter, and 1 to 2 per cent oil, is a valuable by-product; in fact, on account of the demand for it, the scrap can be considered to be the main product of the industry and the glue to be of only secondary importance. At any rate, the manufacture of glue alone would not pay. The better grades of scrap are used for poultry food under the name "chum," while second grades are sold for fertilizer, for which there is always a good market.

The solutions running from the autoclaves or the filtrate from the filter presses are run into vacuum condensers, since the excess moisture in the glue liquor must be distilled off at as low a temperature as possible in order to prevent unnecessary decomposition of the dissolved gelatin. In general, vacuum evaporators consist of a spherical or cylindrical iron veessl, steam-jacketed and provided internally with steam coils immersed in the glue liquor. Sometimes, in modern plants, a type of evaporator used has revolving steam coils; the solutions are thereby uniformly heated and undue frothing from local superheating is prevented. The distilling head is provided with baffle plates and is connected with a vacuum pump and condenser. To conserve fuel, the steam from one evaporator is led through the coils and jacket of the next in a series, on the principle of multiple effect. After concentration to the desired consistency (fish glue contains usually about one-half its weight of water), the product (fish glue) is run while still hot through cloth filters into a receiving tank.

Since fish glue generally does not yield a very good jelly when cooled, on account of the presence of impurities it is employed as liquid glue. To prevent the glue from gelatinizing at room temperatures an acid such as hydrochloric or acetic acid is added, and the adhesiveness of the material is little affected. Since it is not required that this liquid glue be heated or be applied to hot surfaces, there has been a reasonably large demand for it. It has been largely used as a size for straw goods, especially where it has been treated with sulphurous acid, since this latter agent bleaches the straw; it is also employed as a size for textiles. Good grades of fish glue are used for court-plaster, but isinglass is a better adhesive for this purpose. The greatest demand for fish glue comes from the general demand for a liquid adhesive.

The offensive odor of fish glue may also be disguised by the addition of creosote, oil of sassafras or wintergreen, or other substance with a strong odor.

[1] U. S. Fish. Com. Bull., 1901, pp. 97-102.

Machine Guns for American Aircraft

The Browning machine gun has successfully undergone a test to determine its value for use with aircraft. This is one of three types of machine guns with which the rate of fire can be so synchronized with the revolutions of the propeller of a tractor airplane that the gun can be fired by the pilot of a combat plane through the revolving blades. Firing in that fashion, it is necessary to aim the machine gun by steering the plane directly at the target. The direction of the plane gives direction to the fire, and the pilot can fire the machine gun while controlling the plane.

Airplane propellers revolve at from 800 to 2,000 r. p. m. The machine gun is connected with the airplane engine by a mechanical or hydraulic device, and impulses from the crank-shaft are transmitted to the machine gun. The rate of fire of the machine gun is constant, and its fire is synchronized with the revolving propeller blades by "wasting" a certain percentage of the impulses it receives from the airplane engine and by having the remaining impulses trip or pull the trigger so that the gun fires just at the fraction of the second when the propeller blades are clear of the line of fire.

The pilot operates the gun by means of a lever which controls the circuit and allows the impulses to trip the trigger.

The test given the gun was severe. A gun was mounted on the frame of an American combat plane and connected with the airplane engine. The test was conducted on the ground, and in place of the propeller a metal disk was attached to the crankshaft. The gun was then required to register hits on the metal disk as it revolved at varying speeds from 400 to 2,000 r. p. m. The slightest "hang fire" or delay in action on the part of the gun would have been shown by the failure of the bullets to hit precisely on the spot on the disk representing the center of the zone of fire. The gun functioned perfectly.

The gun to be used with aircraft is the heavy type with the water jacket removed.

Besides the Browning, the United States will also employ the Marlin Aircraft gun as a synchronized weapon. Several thousand of these have been manufactured and the gun is in quantity production.

The Lewis Aircraft machine gun is used by the British, French and American forces, but for a different purpose. In a two-seated combat plane, fixed machine guns are mounted forward to be operated by the pilot, and flexible guns are mounted to be operated by the observer in the rear seat of the plane. The observer operates Lewis guns on flexible mounts, firing to right or left of the plane.—*Aviation.*

German Cunning

An important example of German duplicity is found in the patents issued, both in Germany and other countries, covering the Haber process for the fixation of notrogen. After the war began, and the subject began to be of importance to other nations, investigations showed that the patents were so vague, and so much essential information had been omitted, that it was impossible to work the process from the descriptions given. In England a large force of chemists undertook the investigation of the process, and it has required two years of unremitting labor to work out a method of ammonia synthesis according to the Haber method. During this investigation, it may be noted, a number of improvements have been developed for which patents have been granted to the individual discoverers, which patents have been assigned to the British Secretary of State for War.

Rescuing the Art Treasures of Venetia—II

From the Air Raids of the Austrians

By Commendatore Dr. Arduino Colasanti[1]

[CONCLUDED FROM SCIENTIFIC AMERICAN SUPPLEMENT, NO. 2219, PAGE 25, JULY 13, 1918]

THE VENETIANS AND THEIR MONUMENTS

In a democratic nation, however, the army is only the people in arms, and the sentiments of Italy's soldiers are those of the whole people.

It hurt me more than I can tell, and I suppressed with difficulty the intimate pain it gave me, but I had to fight against this sentiment which, in Venice especially, did not want to surrender to the inexorable necessity of seeing the brightest gems of its crown of beauty removed to a distance. Portraits of Doges and Doges' wives, of Procuratori and Admirals, of Patricians and courtezans, pictures of festivals on its lagoons and canals, saints in robes of purple and ultramarine, flights of angels on skies of mother of pearl, such as bend only over lagoons, does it not seem to you that all of this would grow wan with nostalgia the moment it was away from Venice? For, as Ojetti once remarked, in Venice the palaces and hovels, stones and water, mosaics and frescoes, Gothic sculptures and Conquecento canvases, San Marco and the Church of the Salute, the bronze horses and the basilica and the glass of Murano, are one single thing, single and unique, one single treasure, incomparable and unsubstitutable, alive like a living body. It seemed that taking the pictures away from the palace and churches was not saving Venice, but dismembering her. This was a noble pride and a desperate passion. If she had to be stricken, if she had to be destroyed, if she must agonize and die, Venice desired to agonize with the solace of her art; she wished to die adorned in all her loveliness, together with all her beauty.

Monument to Bartolomeo Colleoni, in Venice

But even this resistance was conquered little by little and the Venetians, who at first gathered in sadly commenting groups about the spots left vacant by their monuments, are now beginning to accustom themselves to the appearance of their city transfigured by the war.

Transfigured, but not diminished. For perhaps never as in this tragic hour has the beauty of Venice been so complete; it certainly has never been so near to our heart. Cloistered in her proud suffering, anxious in heroic waiting for her doom, she is a vision that will recur to my mind whenever the profound sadness of life shall be presented, upon a background of color and splendor.

Through her silence, her solitude, her mystery-filled darkness, the expectation of the miraculous apparitions her ancient artists handed down to successive ages pass again like a shiver.

Deprived of the cosmopolitan crowd of her visitors, restored completely to the jealous, trembling love of her sons, she is now really the unique city, where, among the visions of art appears a hope of oblivion, a promise of joy.

And when I hear the cannons thunder from Cape Silé and from the sea-coast of Cotellazzo, and think that such a treasure of beauty can be the object of the hungry craving of an enemy who is deaf to every scruple, I feel that if the peril be renewed but for an instant every Italian will say to himself that life is not the greatest of good things.

THE REMOVAL OF THE EQUESTRIAN STATUES OF ERASMO GATTAMELATA AND BARTOLOMEO COLLEONI

While the salvage of the works of art in the regions closest to the line of battle was going on with feverish but orderly haste, the labor of removal was being intensified elsewhere. Rovigo, Vicenza, Verona, Bassano, and Brescia emptied their museums and churches; Mantua saw the treasures of her ducal palace, including the apartments of Isabella d'Este, taken away; all the valleys of the Polesino, Bresciano, Vicento, Veronese, Mantovano and Garda were gone through and cleared of everything of importance they contained. From the famous doors of S. Zeno to the choir stalls in the Church of S. Maria in Organo, from the enormous "Victory" of the Roman museum at Brescia to the paleolithic antiquities of the little museum of Cologna Veneta, from the Rubens of the Museo Patrio at Mantua, showing the Gonzaga family adoring the Trinity, to the magnificient Romanino of Salo, all was rapidly packed, loaded and shipped.

At Padua, which I made my headquarters during the greater part of November, and where the enemy's aerial attacks vented themselves with the most criminal ferocity upon the monuments and the unarmed people, nothing of importance was left. The miraculous relics of the Duomo, Santa Giustina and the Church of St. Anthony, the very rare Giovanni d'Alemagna, Giotto's "crucifixion," the Bellano of Santa Canciano, the statues in the St. Felix Chapel of St. Anthony's, the bust of Bembo by Cattaneo, the two cherubs surmounting the coat-of-arms on the DeRicellis monument, first flower of the art of Tullio Lombardo, and a hundred other pictures and sculptures took their way into temporary exile along with Briosco's superb bronze candleabrum, the glyptic masterpiece of the Renaissance, and with the bronzes and tera cottas executed by Donatello for the altar of the Saint, which was taken down, piece by piece.

But a specially serious problem was put before me almost at the beginning, when it was proposed to lower the collossal equestrian statues of Erasmo Gattamelata at Padua and Bartolomeo Colleoni at Venice (both Captains-General of the Venetian Republic) and send them away to safety.

I turned at once to experts, but their replies were not encouraging. So I had a commission of engineers appointed, but this reported that at such a moment it was impossible to execute an undertaking of such great importance and responsibility; even the most noted Venetian contractors and architects, called in at the last, refused to undertake the responsibility of the task.

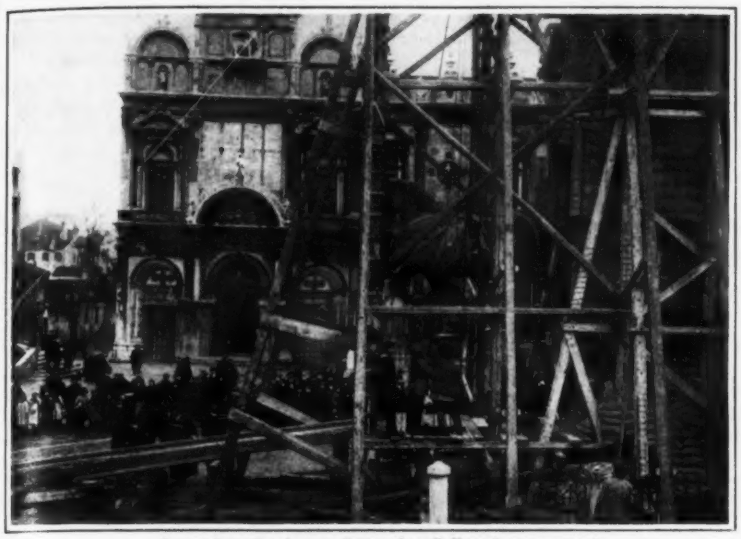
Then I determined to go ahead myself; I sent to Rome for some clever workmen, led by an experienced foreman, and set to work.

One of the most famous English writers on art asserted in the *London Times* recently that the Italians could not remove the Colleoni monument without performing a feat that was comparable to one of the labors of Hercules. But immediately afterwards the same authoritative writer announced the removal of this equestrian statue and in commenting on it gave credit to the exceptional ability of the engineers of whose services Italy was able to avail herself. All this was very flattering to me, for I am not an engineer at all, and it was only my love of art that made me able to bring to a successful issue an undertaking that had been judged to be of such difficulty, and this without the immortal masterpiece suffering the slightest scratch.

However, the task was not accomplished without serious trouble, for, though no difficulty was encountered in lowering the Gattamelata group and the figure of

[1]The Commendatore Dr. Arduino Colasanti, author of the following article, was the official representative of the Italian Ministry of Public Instruction at the San Francisco Exposition in 1915. He is Vice-Director of the Direzione Generale delle Belle Arti e Antichita, which has charge of all matters of art and antiquities in Italy, and is chief of its Bureau of Modern Art. Corrado Ricci, one of the greatest art critics in Europe, is chief of this department, and Dr. Colasanti is his "right hand man." He is the author of many authoritative books on art, among them being one on "Baroque Houses and Palaces in Rome," monographs on Gentile da Fabriano and Lorenzo and Giacomo Salimbeni da Sanseverino; but his most important work yet published is the great volume on "Byzantine Art in Italy," which is the classic authority on the subject.

In this article, translated by Arthur Benington, Dr. Colasanti describes how he and his assistants rescued the famous art treasures of Venetia, from the on-sweeping tide of Teutonic barbarians, often by almost incredible feats of engineering and oftener at the risk of their lives.



Lowering the horse from the Colleoni monument

Transferring the Colleoni statue to a barge

Colleoni, we were much embarrassed when it came to getting the horse of the latter monument down from its pedestal.

In drawing up an approximate estimate of the weight of the colossal group I had nothing on which to base it except my experience in taking down the equestrian statue of Gattamelata and that of Marcus Aurelius in Rome a few years ago. But when the figure of the warrior had been removed and the great hole under the saddle was visible on the horse's back, I observed with astonishment that the bronze was more than twice as thick as normal. It measured two centimeters and three centimeters ($\frac{9}{10}$ of an inch) at the edge of the aperture, and in other places reached four centimeters (more than an inch and a half), while it is highly probable that the hoofs of the enormous beast are solid or almost so.

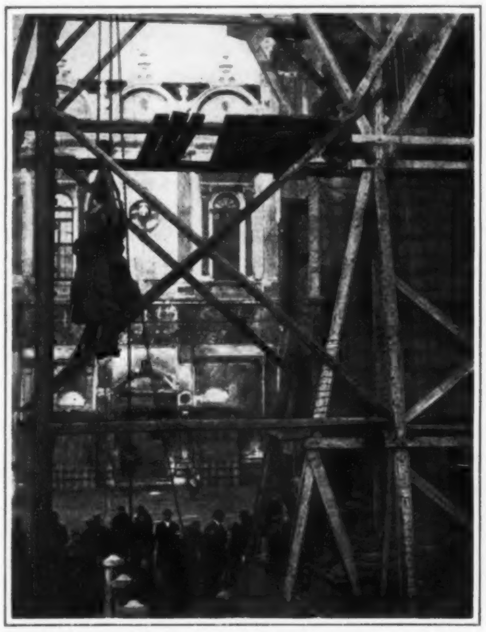
At first sight I seemed to be able to draw from this detail a decisive argument to clear up the disputed question as to the author of the monument, but afterwards I had to revise this opinion.

It is well known that the paternity of this work has long been a disputed point. Is it that of the Florentine Andrea Verrocchio or the Venetian Alessandro Leopardi? There are some writers who uphold a theory intermediate between these diametrically opposite opinions, but even here the views are far from being in accord. For example, Adolfo Venturi attributes the horse to Leopardi and the rider to Verrocchio, while Reymond holds the exact contrary.

Vasari's story—which is not generally credited—is that Andrea, indignant over the decision of the Venetians to divide the work between him and Bellano, smashed the legs and head of his model and returned to Florence. When the rulers of the Venetian Republic threatened to cut off his head if he ever should dare to show himself there again, he replied that he would take good care not to, for it was beyond their power to replace heads they chopped off men, far less such a head as his, which knew so much that it could replace the head it had chopped from the horse. But if there be nothing to prove the truth of this pretty story, and the documents contradict Vasari's succeeding assertion that Verrocchio mended his model and cast it in bronze, the detail that Andrea took the completed model of the horse from Florence, finds confirmation in the plea he made in 1481 to Ercole I d'Este that the latter would exempt him from payment of the transportation tax on "horse of tow, which is a fine fancy." (Un cavallo di stracci che è bella fantasia).

When Verrocchio died in Venice in 1488, he left to his pupil Lorenzo di Credi the task of finishing the equestrian monument, but it is certain that the model of the horse and rider had now reached a point at which it was possible to make the molds for the wax to be applied to the so-called "anima," for Lorenzo, a few months after his master's death, on turning the commission over to the Florentine sculptor, Giovanni Andrea di Domenico, declared that the figures of both horse and rider "had already been executed in clay."

Why this contract was not carried out, is not known. The fact is that in order to get the monument finished, the Venetians, in January, 1489, had to grant a safe-conduct to Alessandro Leopardi who was then under sentence of banishment for forgery. But the work was not finished before1492, as is proven by a letter which the orator Taddeo Vimercati wrote to the Duke of Milan in August of that year, and was unveiled in public only on March 21, 1496, according to the attestation of the diary of Sanudo.



Lowering the figure of Colleoni for removal to safety against Austrian attack

What happened between the first months of 1489, when Leopardi returned to Venice to translate Verrocchio's model into bronze, and the second half of 1492, when the group seems to have been finished and cast, but not yet mounted?

It is evident that the great thickness of the bronze of the Colleoni corresponds to an identical thickness of the wax of the model. This might indicate that the artist had actually modeled his work in wax, as was often the practice of the Renaissance sculptors. But as Verocchio had left the model of the monument in clay, it might be argued that Leopardi remodeled the group entirely, that, in fact, the sculptor and founder of the equestrian statue that has come down to us were one and the same person.

Thus this removal of the monument would definitely settle the controversy over the authorship of the admirable work in favor of Leopardi, who solemnly carved his name upon it.

But—with the passing comment that the presence of the signature proves nothing, for often only the name of the founder is recorded on bronze monuments, as, for example, in the bronzes of the Zeno altar in St. Mark's—I observe that the unusual thickness of the wax and bronze may be explained also by the inexperience of the founder who, fearing that the various "flows" would not reach the extreme parts of the molds, might have insured himself against the danger by making the layer of wax thicker, thus preparing a wide space for the flow of molten metal.

In Venice, the art of bronze-founding had not reached the perfection it had attained in Florence. The technique of the Gattamelata and Colleoni monuments which I have studied closely and minutely for several successive days, gives me proof of this. Exquisitely refined in the former, in which Donatello carved—I might almost say tormented—every part of the bronze with perfect mastery, in the latter it has a ruggedness that has never before been noticed. One marvels to see Reymond extol the delicacy of the ornamentation of the saddle and trappings and just from this alleged perfection of carving draw arguments in support of the Florentine origin of the horse; and one wonders to see others contrast the decorative severity of the armor of Colleoni with the richness of the horse's harness, as a proof that the work of Verrocchio prevails in the one and that of Leopardi in the other.

As a matter of fact, the decorative motifs are precisely the same in both man and horse; they were not even directly modeled by the artist but impressed on the soft metal with identical stamps, which served both for the visor of the rider's helmet and for those of the horse's trappings, for the ornaments on the armor and for those of the harness. It is even possible to establish the length of the different types of matrixes that were used, for the sculptor did not trouble to conceal the junctions of the molds by retouching them. The very opposite of what is to be seen in the Gattamelata, not only is there not the smallest trace of retouching here in this bronze, but, to an artist who left the bubbles of fusion untouched, even the finishing of the wax and plaster must have seemed a useless waste of time. In putting this masterpiece of equestrian statuary into bronze, he did not rise above the ordinary knowledge of the Venetian founders of bells and cannon.

I postpone discussion of this argument until Corrado Ricci (who has promised it) shall have had an opportunity to analyze the bronze of the Colleoni, but the character of its patina and the color of a few spots that have been exposed tell me already that it is of the same nature as that of which bells were cast, with much tin and little copper, so as to obtain an alloy that flowed very easily but was hard and refractory to retouching.

The dismounted figure of Colleoni. The author of the article, Dr. Colasanti, is distinguished by the cross

A DARING HYPOTHESIS: THE ASSISTANCE OF LEONARDO?

All this is inconsistent with the spirit and the predilections of Verrocchio's art, in which the influence of his early education as a goldsmith never diminished. The exquisite ornaments on the breastplate of his "David," the marvelous armor of the "Juliano de Medici" in the Dreyfus collection at Paris, and of the "Scipio" in the Louvre, the decoration of the bust of Lorenzo the Magnificent in the house of Mr. Quincy Shaw of Boston—perhaps a work of his school—are prodigies of perfection, marvels of the carver's art.

The decorative part of the Colleoni monument, however, is referred to Leopardi, and there is no foundation for the distinctions made by Reymond and Venturi. But are we to believe that in the four years that elapsed between his return to Venice and the finishing of the work the artist awaited only the addition of a few stamped ornaments and the fusion which had been made easy by the increased thickness of the wax?

I may be mistaken, but it seems to me that there is a screaming contrast between the Colleoni monument and all the other works of Verrocchio. Nothing of the most exquisite sculptor of the "David," of the "Madonnina" in Santa Maria Nuova, of the child with the dolphin in the Palazzo Vecchio, ever gives a hint of the great change that must have taken place to bring him to express in the rugged, enormous, massive condottiere the image of the fierce fighter, the personification of determination and energy, the eternal type of warlike strength, the figure of the raven that hovers over the fields of battle and of death.

Andrea del Verrocchio, in the grace of his Madonnas and Bambini, in the elegance of his decorative inventions, seems the spiritual brother of the delicious Desiderio da Settignano, and his very masterpiece, the "Incredulity of St. Thomas" in Orsanmichele, is at the highest point of the line that marks the progress of his artistic genius, but is not detached therefrom.

Much less can an exceptional work like the Colleoni find a place in the activity of Alessandro Leopardi. This man was for a long time known in Venice only as a worker in the mint, artificer of the figure of Christ in the die for the ducat. Even in the Mint of Venice he was employed without pay until 1487, and when a salary was assigned to him it was notably inferior to that of artists whose names are lost in time like a flight of ghosts. Even in the safe-conduct of 1489 he was designated as "master stamper of the ducat in the Venetian mint." His later works, such as the "Moors" of the Orologio and the pillars of the Piazza San Marco exclude the possibility of his ever being able to soar to the supreme heights of creative genius.

To explain the appearance of a miraculous work like the Colleoni, one feels that it is necessary to admit, in addition to Verrocchio and Leopardi, the intervention of a genius superior to all others, one that may at least have suggested an idea, or furnished a sketch, and the mind turns instantly to Verrocchio's great pupil, Leonardo da Vinci.

I do not mean at this time to give precise proofs, for I intend to take up this argument exhaustively as soon as the feverish work in which I am still engaged in Venetia will permit; but, keeping before one's mind the little figure of a horseman seen to the left in the "Adoration of the Magi," begun by Leonardo in 1481; a drawing with the head of an emperor, existing at Turin; the "Condottiere" of the Malcolm collection, executed about 1478; Leonardo's numerous studies for the equestrian statues of Francesco Sforza and Gian Giacomo Trivulzio; many pages of the Windsor and the Codex Atlanticus; remembering that the great artificer, in a letter to Ludovico il Moro, called himself a sculptor, and that Lomazzo mentions a horse entirely modeled by him, it does not seem impossible to give at least the value of a hypothesis to what is now more than anything else an impression made by indefinable and not yet precise judgment, the echo of the profound emotion aroused in me by my intimate colloquies with the immortal masterpiece in those never-to-be-forgotten hours in which the work of art confessed its secret life to a soul that is worthy to comprehend it.

Gabriele d'Annunzio, who shared with me the expectation and the emotion of the moment in which after almost 422 years the gigantic mass descended from its tall pedestal, said to me that the fate which made our labor necessary had the virtue, by bringing the masterpiece so close to us, of making us love it more intensely. And the poet's intuition did not deceive him.

I shall never forget the indescribable spectacle of beauty that was placed before our souls rather than our eyes, at the moment when the barge bearing the enormous knight and the ponderous horse moved off slowly from the bank of the Piazza San Giovanni e Paolo and headed toward the open lagoon. In the last gleam of twilight the rows of houses mirrored in the picturesque canals lost their outlines, grew larger in the obscurity and assumed unreal appearances like things in a dream. Then, little by little, from that sea of shadow and silence emerged only the campanile, slender, aerial, springing to the sky like the aspirations of men toward the first stars.

The profile of the enormous bronze mass seemed to blend with the line of the distant hills, and at that moment I felt really that the masterpieces of man's genius, like the formations of nature, can never die for their nature is akin to that of the rocks and planets.

Then, when the night came, down more darkly and along the horizon there was nothing to be seen but a succession of murderous flashes upon the Grappa and the Montello, it seemed to me that the divine symbol mounted again upon its horse, now no longer on the Piazza di San Giovanni e Paolo, but over yonder, on the banks of the Piave, with the gesture expressive of his determination to victory.

Changes in Oceanic and Atmospheric Temperatures

And Their Relation to Changes in the Sun's Activity[1]

By Prof. Fridtjof Nansen of the University of Kristiana

THE primary aim of the research was to find the relations existing between oceanic and atmospheric temperatures. The surface temperature of the water in various parts of the North Atlantic at the coldest time of the year formed the foundation of the first study. When the region covered by the data is divided into approximately equal areas, the temperature curves of these areas are found to be parallel. It is evident from the form of the curves that these changes of temperature taken as a whole are not due to changes in the water-masses transported. A relation does appear, however, between these changes and the prevailing direction of the wind, as deduced from atmospheric pressure gradients. Where the wind turns south of (*i. e.*, is directed south of) its average direction over a period of years, the temperature of the water is lower than the average for the same period, and vice versa. A similar parallelism between wind direction and water temperature appears along the coast of Norway; the effect near the coast is based upon the direction of the wind with respect to the land, as well as upon the season of the year. The air temperature variations on land appear earlier than the variations in water temperature.

Certain periodicities appear in all the curves of oceanic and atmospheric temperatures, but they vary in type. At the same time a relation also appears between these curves and curves of sun-spot activity and magnetic elements. The 11-year period is prominent. An oceanic type and a continental (Eurasian) type can be distinguished. The latter follows the sun-spot curve directly, whereas the former type follows the sun spots inversely. There is also a third and very remarkable type in which the curve changes more or less suddenly from direct to inverse. This sudden inversion is brought out in many curves, comparing stations in different parts of the earth, and the inversion occurs in very many cases at about the year 1896.

When the temperature curves for different months of the year are compared with the sun-spot curves, these three types of agreement again appear in very puzzling and unexpected combinations.

In addition to oceanic and atmospheric temperatures, other meteorological elements (air pressure, wind velocity, rainfall, cloudiness, mean daily temperature-amplitude) show a relation to the sun spots, sun prominences, and magnetic variations, and show not only the 11-year period but also shorter periods of two, three, and five and one-half years.

The fluctuations of the temperature at the earth's surface do not follow directly the variations in the energy received from the sun as determined by the measurements of Abbot and Fowle. The daily and yearly temperature-amplitudes are believed to furnish sufficient refutation of hypotheses based on supposed variations in the absorbing and reflecting power of the atmosphere, as well as of Humphreys' hypotheses as to formation of ozone or effects of volcanic dust. Blandford's hypothesis of the effect of increased evaporation in lowering continental temperatures at sun-spot maxima is also not supported by the facts of tropical land and ocean stations.

The mistake of most authors when they have discussed the causes of temperature changes has been that they took for granted that the average temperature at the earth's surface was directly dependent on solar radiation, and would give a direct indication of heat received. They have not considered sufficiently the fact that a very great proportion of the sun's radiation is absorbed by the higher layers of our atmosphere and that the distribution of heat in the atmosphere is of the greatest importance for the temperatures at the earth's surface. They seem very often to have forgotten that the variations in the sun's activity, and in the so-called "solar constant," and also in the sun's electric radiation, may primarily influence the higher layers of the atmosphere, thus indirectly guiding the distribution of atmospheric pressure and the circulation not only of these higher layers but also of the lower parts of the atmosphere. In this manner the temperature of the higher latitudes may be influenced more than that of the tropics, where the conditions are so stable.

The variation in *pressure gradient* seems much more closely related to the temperature of land stations than is the variation in air pressure itself. For instance, the Colombo-Hyderabad gradient runs parallel to the temperature in the Himalayas but opposite to the temperature at Batavia, while Bombay forms an example of those strange reversals occurring about 1896. The Iceland-Azores gradient has exactly opposite effects in Norway and in mid-Atlantic. An increase of air circulation may thus have opposite effects in different regions. The sun spots and magnetic elements sometimes oppose and sometimes agree with the variations in pressure gradients.

Various periodicities appear in the sun spots as well as in the terrestrial phenomena. In the sun spots there is an 8-month period corresponding with the conjunction or opposition of the planets Venus and Jupiter with the sun. This same period occurs in the North Atlantic gradient, and was found by Krogness in the magnetic declination at Kristiania. There are also periods of six and twelve motnhs in the magnetic elements, due to the position of the earth. The combination of these 6, 8, and 12-month periods gives a 2-year period for the magnetic and meteorological elements on the earth. But in the fluctuations of the sun spots a similar period of two years is also discovered, and especially noticeable are indications of minima every second year. Before 1896 there is an agreement between the 2-year minima of temperature at certain stations and the corresponding sun-spot minima, but the agreement is remarkable in that the greatest depressions in the sun-cpot curve coincide with the smallest depressions in the temperature curve; this relation ceased about 1896, hence the peculiar inversion already referred to.

Other periodicities have been recognized. A 32-33-month period at Batavia may be a combination of the 2-year period already referred to and a 3.7-year period suspected by Lockyer. Secular changes of relatively long period (35 years and over 100 years) also are probable. The researches of Clayton have recognized correlations in daily temperature and pressure flucuations at various stations over the earth and the fluctuations in the daily heat radiation of the sun are measured by Abbot and Fowle, the same three types appearing in these meteorological variations as have been noted in the long-time variations. Krongness recognizes 14-day and 27-day periods in magnetic storms, as well as in air-pressure gradients, wind, and temperature, in northern Norway.

To summarize the results of these investigations: In different groups of areas on the earth the meteorological elements (temperature, barometric pressure, rainfall, etc.) fluctuate or pulsate, so to speak, in time with one another, while in other groups of areas the fluctuations or pulsations are exactly inverted, and finally some areas show transition stages between the two. The result of all this is a very complicated picture of the meteorological fluctuations. But by means of appropriate analyses we see that from this complicated and apparently chaotic set of fluctuations there arises a clear picture of the very intimate realtion between all these variations and the variations in the sun's activity. We have seen that even changes of very short duration in the sun's radiation (of heat as well as electricity) are distinctly repeated in our meteorological conditions and in the surface temperature of the ocean. The effects of the solar variations are probably transferred by means of variations produced in the distribution of pressure in our atmosphere. Changes in solar radiation probably first affect the higher layers of our atmosphere, and thus create an unrest which in turn is transmitted to the lower strata near the earth's surface.

Such dynamic changes will produce different effects in different regions of the earth. But by thorough and complete analyses of the great meteorological material now at hand it may be possible to find the general rules.

For this purpose it will also be of the greatest importance to have the wonderful researches of Abbot and Fowle continued with the greatest possible efficiency. These investigations of the sun's radiation of heat, which they have been carrying on for a long series of years at Washington, Mount Wilson, Mount Whitney, and in Algeria have given us the remarkable revelation that our sun is a variable star, the most important discovery that has been made in this field in many years.

[1]An abstract of a lecture delivered before the Washington Academy of Sciences, reviewing a work by the lecturer and Prof. Björn Heland Hansen, of the Museum of Bergen, under the title, *Temperatur-Schwankungen des Nordatlantischen Ozeans und in der Atmosphäre. Einleitende Studien über die Ursachen der klimatologischen Schwankunfen.*

The Åland[1] Islands

The archipelago near Finland known as the Aland Islands has recently sprung into great prominence, owing to the peculiar political situation which had developed between Finland and Sweden subsequent to the downfall of Russia. The reason for this lies in the strategic importance of this group of islands, an importance due to their geographical situation and geologic formation, as is interestingly set forth by Charles Rabot in a recent number of *La Nature*. After remarking that the Aland question is indeed as much a bone of contention between Sweden and Germany as formerly between Sweden and Russia he says:

What then is this archipelago so much disputed, and why does it occupy such a great place in the affairs of the Baltic powers? Neither its extent, its population, nor its resources justify the covetousness of which it is the object. It is composed of four principal islands and a hundred or two hundred islets and rocks, most of which are uninhabited and uninhabitable. The most extensive, called "Aland Earth," is 50 kilometers long from North to South and 40 kilometers from East to West; the three other islands Eckero, Lemland, Lumpurland, are much smaller. The chief town of the Mariehamn District, is a village of one thousand inhabitants, and the remainder of the population scattered over these rocks is hardly more than twenty-five thousand. Moreover, these islands contain neither deposits of metal ores nor specially fertile territories. Their importance comes solely from their geographic situation.

Like both Sweden and Norway, Finland is surrounded by a very large and very dense archipelago containing hundreds of islands, and thousands of islets lying very near each other; it is a sort of crumbling earth which evokes the idea of a continent in process of emergence. But, while around Norway these islands consist of bare rocks or high mountains, around Finland and Sweden they are low,[2] and covered by old forests of green trees, so that in sailing around the coasts of these two countries one has the impression of navigating in the midst of an inundated forest. Around the Southeastern part of Finland, this singular formation undergoes a considerable extension towards the West, to such a degree that it almost entirely crosses the Baltic, and very nearly reaches the Swedish Coast. It suggests the idea that it is the dismantled ruins of a dike once running from one shore to the other of this Sea.

This comparison is not merely a figure of speech; so close together are the islands of this long "Causeway" that bridges might be thrown across the Straits that separate them and a railroad built to the very end of the archipelago, like the one built upon the Florida Keys. In this manner the entrance to the Gulf of Bothnia is closed for five-sixths of its width, and the only free passage between the end of the Finland Archipelago and the beginning of Swedish territory is not more than 40 kilometers wide. The Aland Islands are found at the Western extremity of this barren and upon the very borders of the Strait which it bounds, and which for this reason bears the name of the Aland Sea—hence their strategic value. They command the passage between the Baltic and the Gulf of Bothnia, and the numerous harbors hidden among the folds of their extremely irregular shores; in this latter arm of the Sea it would be possible for a squadron to keep an entire fleet bottled up. The archipelago also has openings towards the South, towards the Gulf of Finland, and, therefore, constitutes an excellent naval base commanding this area. Aland, therefore, is the key of the Central and Norther Baltic. Moreover, these islands are scarcely more than 40 kilometers from Swedish territory, and only about 60 kilometers from the entrance to the Fjord of Stockholm. The arm of the Sea which separated them from Sweden is often visited by frightful tempests; its waters, which are almost fresh, and which are stirred by violent currents, rise as soon as the wind freshens, and in heavy weather become so dangerous that the mail steamers running between Stockholm and Petrograd, by way of Finland, are afraid to risk the passage; but in summer calms are frequent, and at this season lighters could easily cross the Aland Sea and transport a body of troops to Sweden in a matter of three or four hours at most; the operation would be equally easy in the opposite direction. Once at Aland, Swedish troops could easily reach the coast of Finland. It must be added, that in very severe winters an ice dam unites the two shores of the Strait. This occurred nine times during the nineteenth century. Aland is, therefore, not merely a port of entry to the Gulf of Bothnia, but also an easy passageway across the Baltic from East to West.

During the first half of the last century Russia practiced an aggressive policy towards Sweden, and in pursuance of this made a military base of this archipelago, erecting there the Fortress of Bomarsund. Stockholm was then in reach of the Russian guns. This situation came to an end in the Crimean War. In 1854 Bomarsund

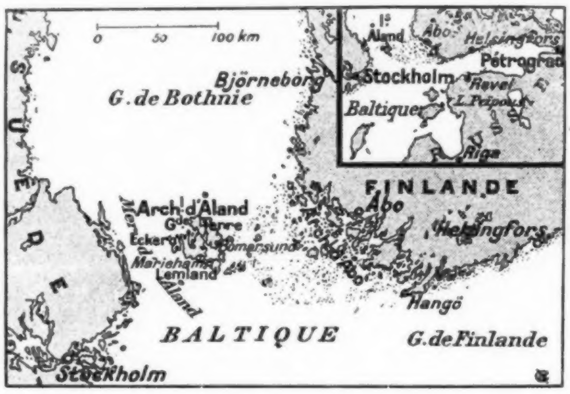


Chart of the Aland Islands

was destroyed by the allied powers, and a clause added to the Treaty of Paris forbade Russsia thereafter to erect any fortification on this Finnish territory, or to maintain there any military or naval establishment. Afterwards Petrograd abandoned this hostile attitude towards Sweden, and in the years preceding 1914, if the relation between the two countries were sometimes strained the wrong way was not always on the Russian side. Acting upon German suggestions, adroitly devised to incite national chauvinism, a certain Swedish political group has taken every occasion for expressing fierce hostility towards "Muscovy." At the beginning of the war, when fortifications had been raised on the Aland Islands to insure their defence against Germany, there was a corresponding outburst against Russia among the "Activists," and the "Germanophiles" of Sweden; agents from Berlin naturally threw oil upon the blaze, and war would have broken out, but for the opposition of the liberal and socialist elements in Sweden. Up to 1916 the situation remained threatening, but when Russian Imperialism had been abolished by the revolution the matter was supposed to be closed.

But there soon began to be an increase of anarchy in Finland; molested by the Red Guards, the inhabitants of Aland, Scandinavians whose maternal tongue is Swedish, demanded from King Gustav V, the annexation of their islands by his kingdom. The Swedish Government hesitated to take so serious a step; the question was peculiarly delicate for the reason that the population of Finland belongs to different races. Among the three million inhabitants there are about four hundred thousand Scandinavians who speak Swedish; the remainder speaking Finnish. Among the former many ask nothing better than to become Swedish again, as they were previous to 1808; but the Finns were resolutely hostile to annexation, and fierce partisans of the independence of their country. When the Activist press of Stockholm, before the Russian Revolution, called for the occupation of Aland, the Finns hotly demanded that Finland should have the right to retain these islands. For fear of offending the national sentiment of their neighbors, the Swedish Government confined itself to sending a corps of police to Aland to insure the protection of the inhabitants against the Bolsheviki. But scarcely had they disembarked when the Germans arrived in force and installed themselves in the Island.

Once more Sweden found herself the victim of an abominable trick at the hands of Germany. When the agents of Germanic propaganda in 1916 incited the Swedes against Russia on the subject of the erection of fortifications at Aland, the Berlin Chancellery had nine years previously authorized the Czar to erect military establishments upon these islands, as has been learned from the revelations made by Trotsky, confirmed by Isvolky, the former Minister of Foreign Affairs in Russia. And at the very moment when the Swedes were timidly about to set foot in the eagerly coveted archipelago, the Germans supplanted them. As a consequence of their occupation, Stockholm now finds herself lying under the guns of the Kaiser's fleet, a result not foreseen by the Germanophiles on the borders of the Maelar. The affair has certainly not been terminated; Aland will continue to claim the public attention, therefore, it was useful to explain the reason why.

Editorial Note.—In a recent speech before the Reichstag Foreign Secretary Keuhlmann stated that an agreement had been reached by which the fortifications on the Aland Islands, in the Baltic, were to be removed, but that a final decision had not yet been reached regarding the future of the islands.

"We hope and desire, however," he said, "that this question will be so settled that the maximum guarantee can be given that to the advantage of all dwellers on the Baltic coast the non-employment of the islands for military purposes may be assured for all time."

[1] This word is frequently spelled incorrectly through the omission of the diacritical sign "°" above the initial "A," which gives this letter in Swedish the sound of a long "°." The omission of the diactritical signs used in the Scandinavian tongues sometimes causes an annoying confusion. For example: In the southern part of the Baltic Sea, just opposite the Gulf of Sweden, we find the Island of Oland, the first letter of which is pronounced like "eu" in French because of the diaeresis over the "O"; but not-knowing the significance of this sign many people pronounce the word Oland, thus confusing it with Aland.

[2] The loftiest are not more than 40 meters high (130 feet).

The Slide Rule

When making a circular slide rule I devised a method of getting the exact position of certain gauge marks, which, I believe, is not generally known, and may prove useful in both setting and reading the slide rule.

Generally speaking, a 10-inch slide rule is said to give two figures accurately, with the third one guessed. For example, it is guess work to set the cursor at 917; but, using the slide as a vernier, it is possible to get even four accurate figures, and often one has a very good idea of the fifth figure.

This method is alluded to by Pickwarth, who says it was brought to his notice by Mr. M. A. Ainslie, but it is not developed at all in his book, and it is said to be of little practical value. However, I have found it quite useful in many ways, *e. g.*, I can prove that a certain gauge mark on a German slide rule in my possession is wrongly placed.

If the 1 of C is placed opposite 1.5 of D, then every division of C=1.5 of a *similar* division of D underneath—*e. g.*, 4 is over 6 and 4.1 is over 6.15.

So, too, if 10 of C is placed over 7.5 of D every division of C corresponds with .75 of the division of D under it—*e. g.*, 8 of C coincides with 6 of D and 8.1 with 6.075.

And the same is true with intermediate values—*e. g.*, if 1 of C is placed over 1.01 of D, 1.01 of C will be over 1.0201 of D. And similarly with the other end.

The application of this principle is obvious. Supposing you wanted to mark out 3.1416 as accurately as possible: this can be done in several ways. One is to set 10 of C over 4.16 of D. Then each division of C=.416 of a similar one of D just under it. The nearest mark in my rule to 3.1 of D is 7.45 of C. Place this exactly over 3.1, then 7.55 (which is the unit distance off), is over 3.1416. On looking at the exact position of the 10 of C, it is seen to be rather more than 3.1416. Another way of getting this gauge mark is to place 1 of C over 1.416 of D. Then each division of C=1.416 of a similar one on D just under. Now, the nearest marked division on C to 3 on D is 2.12. Place this over 3, then 2.22 will mark out the number pointed out by 1 of C—*e. g.*, it is 3.1425, about. Most people will find these two marks nearly coincide; the sought-for position is between them.

Conversely, the same principles can be applied to read settings. To read 155x27: mark the result with the cursor. It is between 4.1 and 4.2. Move the slide to the right until an unit division=the space between 4 and the cursor line. This will be when 2.16 is opposite 4 and 2.26 is opposite the cursor line. Then 1 of C is over 1.85 of D; therefore, the unit division 2.16—2.26, exactly=1.85. The reading is then 4185.

As an example of using the other end, we can find out the square root of 6. This is obviously between 2.4 and 2.5. Move 10 of C to the left until 4.85 of C is over 2.4, and 4.95 (an unit distance off) is over the cursor line. Then 10 of C is just over 4.95 of D, showing that a division of C=.495 of a similar one of D. So the result reads 2.4495, which happens to be correct to 5 figures.

Owing to the irrationality of the marks on slide rules, units being divided sometimes into fifths and sometimes into halves, etc., it is often impossible to find a division that will coincide as is required. However, it is nearly always possible to devise some way of tackling the difficulty—*e. g.*, another way of getting 3.1416 would be to set 1 of C over 1.16 of D, then the marks on C are .2 apart. Consequently, each division of C=1.16 of .2. But we want 1.16 of .1, and this can be obtained by setting the 1 of C over 1.08 of D. Then if 2.88 is placed over 3.12, 2.9 will mark 3.1416 nearly. Or it is always possible to take too high a reading and one too low and average out the result.

What I find is the greatest difficulty in using a slide rule is accuracy in setting. One needs a fine adjustment. Something of the sort on the Columbia slide gauge used to cost 1s. 3d. before the war, and I do not see why our makers should not add this accessory.

I have made a magnifying cursor with the aid of a fenestrated cylinder, formed out of notepaper and glue, with a Ramsden eyepiece X 10 as a magnifier. This is easily attached to the cursor frame by two hooks of piano wire joined by an india rubber ring.—G. Burton-Brown in *The English Mechanic*.

The Sun's Equatorial Rotation

A Neglected Problem of Celestial Physics

By N. Johannsen

A POINT at the sun's equator makes a complete rotation in about 25 days. At the poles it takes more than 30 days—the speed of angular rotation gradually increasing from the poles to the equator. The true cause of this greater angular speed of the equatorial surface seems to have escaped attention thus far.

The phenomenon is due to the internal convection currents, which carry large masses of superheated gases from the interior to the surface, and back again into the interior after those masses have lost part of their heat by radiation. The working of these currents is peculiar. Their gases, when arriving at the surface in a superheated condition, will expand into the thin lower atmosphere (the photosphere), forming huge gaseous mountains, known as "granules," many miles high. Within these mountains or clouds of expanded gases a dense rain of liquid fire drops develops (say, from the condensation of silicon vapors) which emit the dazzling light giving a continuous spectrum and which effect a rapid cooling of the cloud, the same as a gas flame is cooled by the luminous particles within it. The cooled gases accumulate underneath, or in the valleys between the gas mountains and from there sink back, through the so-called pores, into the depths of the sun's body. There they become reheated, whereupon they resume the upward journey—either the same gases or other ones of the same level. Of such luminous gas mountains (granules) there are hundreds of thousands, distributed all over the sun's surface, in close proximity, some hundreds of miles apart.

From the foregoing the very important point can be deduced, that the whole of the visible photosphere consists of gases brought into it by the hot rising currents; not only the granule mountains immediately above the currents, but the valley gases as well. It is also clear

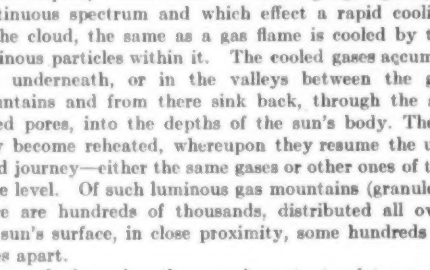
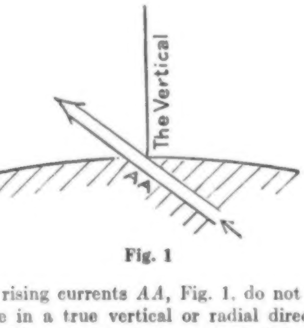


Fig. 1

that if the rising currents AA, Fig. 1, do not enter the photosphere in a true vertical or radial direction, but somewhat off from the vertical, say, to the left, the whole of the visible photosphere is impelled thereby, following up that direction and moving likewise to the left. As this direction is the same as that of the sun's rotation, the photosphere is bound to move quicker than the sun's body, *sliding over it*.

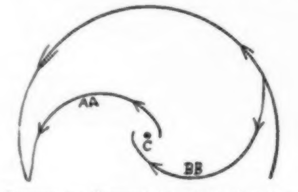
Such is actually the case. The currents do not reach the surface from below in a strictly vertical direction, but somewhat deflected laterally, as indicated by the arrow in Fig. 1. And their gases, once injected into the photosphere in that direction, will strive to continue in that direction. Their upward thrust, up into the thin atmosphere, is soon overcome by the attraction of the sun, which acts like a brake to their rise; such a brake, however, does not check their lateral thrust,



Convection Currents in a Non-rotating Sun
Fig. 2

which, therefore, is continued at the same rate of lateral speed as the gases had when breaking forth from the sun's body. As the photosphere consists of nothing but these gases, the whole of it will partake in the same lateral movement as these gases do.

What gives the hot convection currents their LATERAL course, in addition to the upward one? It is the rotation of the sun. In a non-rotating sun, Fig. 2, the rising as well as the descending currents (A and B) would follow a straight, nearly vertical course. But if the sun *rotates* (Fig. 3), a rising current, AA, moves up in many spiral turns (Fig. 3 indicating these numerous turns by a mere curve) and the downward current, BB, likewise moves in a spiral. A particle near the center c



Convection Currents in a Rotating Sun
Fig. 3

may rotate around the axis with a speed of, say 100 miles a day, but when the convection current AA has brought it to the surface, it rotates with a speed of 100,000 miles a day—a fact which makes it clear that the current AA cannot rise in a vertical line and that, when its gases reach the surface, they will enter the photosphere not in a vertical direction but somewhat off, as indicated in Figs. 1 and 3.

Now a further point turns up. Suppose the gases of current AA, when reaching the equatorial surface, have acquired the same rotary or lateral speed as the surrounding masses of the surface (which they have not, see later), can they enter the photosphere with a *greater* lateral speed than the surrounding masses of the sun's body have? Can they move quicker, laterally, than the surroundings do, which *give* them the lateral speed? If not, there could be no accelerated motion of the photosphere, it would rotate with no greater angular speed than the sun itself.

To answer this question we must first get a clear conception of the pressure conditions prevailing around the sun's surface. And there we are brought before the further question: Why should we designate one part of the sun as "body" and another part as atmosphere, where both parts consist of gas? What constitutes the distinction between the two? This distinction is based on a very marked difference in gravity and compression; a difference which does not set in gradually but almost suddenly, at the so-called surface of the sun. From what reason?

On our Earth the atmospheric pressure doubles from half an atmosphere to one atmosphere when going down to the sea level from a mountain three miles high; it would double again (from one atmosphere to two) in a shaft three miles deep. At a depth of six miles it would double again, from two atmospheres to four, provided the temperature would not change. At a depth of 30 miles (or, say, 40 or 50 miles, from reasons known to the physicist) the compression should double ten times and be a thousand times greater than at sea level. On the sun's surface the mass of a cubic foot of air would weigh about 27 times more than on earth, a fact which should help compression; on the other hand this greater weight is more or less counterbalanced by the expansion due to the great heat, the "absolute" temperature being about 27 times higher there, so the compression, growing with increasing depths, may not be figured too high when assuming it to be strong enough to give the gases the gravity of 1, or nearly 1, at the depth of, say, 50 to 100 miles.[1] Therewith, however, the sun's gases are nearing a state of compression where they become as little compressible as their liquids are, so that any further compression would proceed very slowly. Then the sun's

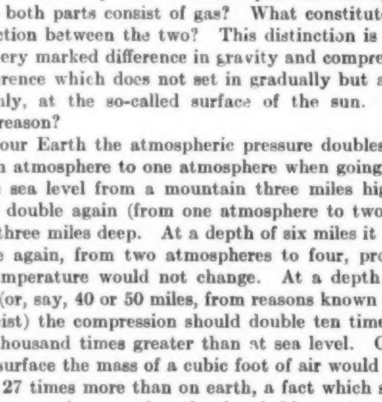


Fig. 4

pressure conditions would be somewhat as shown in Fig. 4: an enormous atmosphere, h, of very attenuated substance and small pressure; a surface section s, or only 50 to 100 miles thickness, with a gaseous compression perhaps ten times greater at its lower side than at its upper side; and below s the sun's body, m, slowly gaining in compression towards the center, c, where it is perhaps 5 times greater than right under the surface section $s\ n$, see Fig. 5. The *pressure* will increase tremendously from surface to center, but not the compression, for reasons stated.

If the sun was not radiating any heat, its gaseous masses would remain at a state of rest, even though the sun itself were rotating. And (an important point for my argument, see Fig. 5, which shows a section of the surface layers) a particle at n, though having a strong

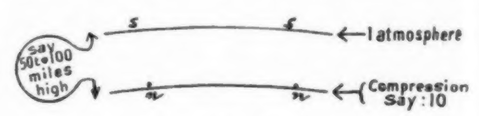


Fig. 5

tendency to expand, owing to its inherent pressure of say, 1,000 atmospheres, and owing to the much smaller pressure further up, cannot follow this tendency because for each particle in the sun the pressure is counterbalanced in all directions—that is, so long as no radiation and cooling takes place. And we should bear in mind that the surface layers as per Fig. 5 do not radiate any light or heat—the sun's radiation emanating entirely from the gaseous photosphere situate above said layers. In consequence the upper layers of the sun's body, above and below n, will not bring about any circulation or any movements of their own, unless stirred by the convection currents. The currents, AA, Fig. 3, will rise because their particles are hotter than the particles above and below n, and the descending currents BB will sink because they are cooler than the sun's body around s and n, but the masses m above and below n have no tendency to either rise or sink and will remain quiet unless activated by the currents. These currents however, do put those masses m, n, s, into very violent action.

Now let us return to the question: Can the current AA (Fig. 3), when nearing the surface s, dart into the atmosphere with greater lateral velocity than the layers $n\ s$ have, which *give* to the current its lateral velocity?

Here we have to consider that the current's gases are much hotter than the $n\ s$ gases. On account of this greater heat they have the tendency to rise into the atmosphere, while the $n\ s$ layers have no such tendency, as explained above. And when the AA gases reach the thin atmosphere they will expand very forcibly. It takes them only a few minutes to penetrate the $n\ s$ layer and to expand from 1,000 to only one atmosphere. Fig. 6 shows in what direction the expansion takes place.

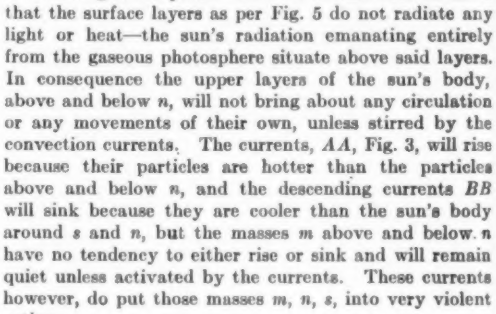


Fig. 6

When the gases of the hot current AA reach the x level and expand, explosion-like, not only the x gases will expand but also those of the y and z levels, a free outlet into the atmosphere offering itself to these gases by way of x, in the direction of the arrow. But before a great deal of the $x\ y$ gases has darted into the atmosphere, a new development sets in, as shown in Fig. 7.

When the current's gases were at the y level they had the same pressure as the surroundings; but when expanding into the atmosphere by way of x, the hot gases remaining at x and y have a smaller pressure, and at

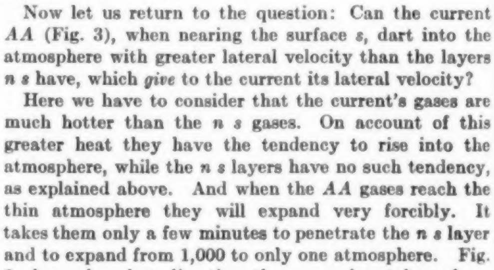


Fig. 7

once the surrounding m gases will dart in, as shown by the arrows in Fig. 7, and close up the outlet at y, whereupon the situation will be as shown in Fig. 8. So the

[1] Tables have been published showing the compression to grow, with increasing depths, at an entirely different and much slower rate. Apparently they have been computed on an erroneous basis.

outflow of the hot AA gases can take place only intermittently, not in shape of a continuous stream. In Fig. 8 the dotted lines show the place previously occupied by the hot gas, into which place the gases of the

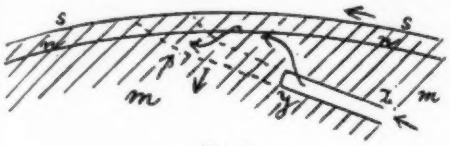


Fig. 8

sun's body (m) will rush from all sides, clashing, forming eddies, and causing a scene of utmost turbulence. The m gases coming from below cannot leave a partial vacuum behind them, and are bound to return downward (as shown by the lower arrows), forming eddies. Those coming from the upper side, however, do leave a partial vacuum behind, into which the hot y z gases will dart (as shown by the arrow starting from y), thus gaining a new outlet into the atmosphere—until, after a short while, this new outlet is likewise closed, the process constantly repeating itself, for each individual AA current.

Without their expansive force the hot gases could not move quicker, laterally, than the surface gases which give them the *lateral* spiral motion; but the expansive force, which gives them an additional forward thrust, in the direction in which they leave the sun's body, makes them move more quickly than the latter, so they slide over it. I repeat, the *upward* thrust, caused by the expansion, is limited by the sun's attraction; the *lateral* thrust is not so checked and is communicated to the whole of the photosphere, the latter consisting of nothing but gases thrown in by the AA currents.

Before the expansive force becomes active, the lateral velocity of the hot gases is smaller than that of their surroundings. The currents lag behind these surroundings (a point discussed later on under "Angular and Linear Velocities.) When rising from one internal level to a higher, quicker-moving level, it takes some time before they are pushed forward sufficiently to assume the quicker lateral motion, and before they acquire it, they have worked their way up to a still higher and still quicker-moving level. So, when appearing near the surface, they lag behind, moving at a slower rotative speed than the surface does. Were it not for the expansive force of their gases, working in the direction of the arrow in Fig. 6, the equatorial photosphere would move the other way, not with a greater angular speed than the poles have, but with a smaller one. In moving in the direction of the arrow they do the same as the gases fired from a gun—these continue in the same direction as they had when still in the gun.

Ascending convection currents meet their greatest spiral deflection right under the equator, therefore the gas mountains rising over their terminals show the greatest forward speed at the equator. Further north and south the deviation becomes smaller, therefore the lesser speed of the photospheric mountains under growing latitudes. At the poles the deviation amounts to little or nothing, and there we see the true (or at least more nearly true) angular velocity of the sun's body, such as is due to its centrifugal force.

As the photosphere forms the lower part of the atmosphere, the latter, too, will be impelled to a greater rotative speed than the mere centrifugal force of the sun's body would warrant. For this reason the spectral lines do not show much of a shifting such as would take place if photosphere and chromosphere had very different velocities.

As to the downward BB currents, these will not act like the rising ones, at their terminals. While the rising currents find their outlets at the open atmosphere, the descending ones are always surrounded by highly compressed material. A feature of their's consists of the fact that they assist somewhat in accelerating the rotation of the equatorial layers, as follows: When leaving the photosphere and sinking below the line s, Fig. 5, they enter the sun's body with a greater velocity to the left than the sun's surface has, and this surplus of velocity is imparted to the upper layers of the sun's body which, in consequence, are made to rotate quicker than they would if the BB currents entered them with no greater angular velocity than the sun's body has. This increase of angular velocity is to a certain extent cumulative; when the rising current AA enters the upper layers, its lateral speed is augmented by the expansion, as explained; this augments its lateral impulse on the photosphere, and this again the rotative energy of the sinking BB gases. As it were, the expansive energy of the AA currents is fully preserved and transferred to the sun's upper layers, increasing their velocity until the growing friction between the sun's upper and its lower levels acts as a brake.

The BB currents need not necessarily go down to the center, even if the sun, as is generally assumed, should be gaseous all through. The various elements contained in it may form layers, according to their gravity, in a similar way as the layers in the chromosphere seem to indicate, whose substances apparently do not mingle, or not fully mingle. In that case there may be interior convection currents confined to the individual layers, or to groups of layers, the lower group always transferring heat to the upper one. Of course, the currents will always carry more or less admixtures from the one group to the other, so that even the elements of the lower levels are represented in the chromosphere.

How does *the appearance* of the granules agree with the assumption that their substance is injected into the photosphere laterally?

If the injections went on quietly and orderly, and if the AA currents would supply the injected material in steady streams, of uniform size and velocity, we would see, instead of the granulation, long luminous streaks or ridges, all parallel with the equator, or nearly parallel.

What we really do see is a mass of short luminous ridges, rice-grain shape. They come and go very quickly. Taking successive photographs, one minute apart, of a small area, the contours of the first one are barely recognizable on the second photograph, while after three minutes they are entirely different—a fact proving conclusively the intermittent character of their formation. The ridges will often shrink to a mere luminous point (a gas mountain) before disappearing.

It is but natural that not all of the ridges have one and the same direction, parallel with the equator, considering the extremely turbulent state of the sun's surface layers from which they emanate; also when considering that a body of superheated gas (such as y z in Fig. 8), though mostly following the forward direction, will dart out into the atmosphere at any place, wherever it meets the least resistance, and that the place of the outlet will determine the direction of the gas jet which follows, the same as the gases of a gun will follow the direction of their outlet. The majority of the outbursts, however, will follow the *forward* direction. Even the jets expanding sideways bring some forward notion into the photosphere, for the reason explained above, in connection with the accelerated motion caused by the BB currents.

To some extent the jumbled appearance of the granules is due to a peculiar "triangular flow" of solar material from the poles towards the center, from there to the equator, and from there back to the poles along the surface line s in Fig. 4. The descending BB currents, such as come from the equatorial surface, bring a rather active rotation into the central masses of the sun, giving them an increased centrifugal tendency, while the currents descending from the poles do not. This centrifugal tendency of the central parts means a suction sideways, in the polar direction, on the masses descending from the poles, causing a share of them to make their return to the surface not in the polar but in the equatorial direction. When these gases, after reaching the equatorial photosphere, flow back to the poles (line s, Fig. 4) they will contribute their part toward the criss-cross appearance of the granules.

How about the equatorial diameter? Is it longer than the axial diameter, and does it thereby give us a clue as to the velocity of the sun's rotation? *i. e.*, not of the photosphere (whose rotation we know) but of the sun's body below it? Many measurements have been made, but owing to variations, either way, a measurable difference between the two diameters has not been established.

Angular and Linear Velocities.—The assertion made in the text above, that rising convection currents lag behind their surroundings, may not seem to agree with current views, according to which the angular velocity of the interior in rotating gas balls is greater than that of the surface. This is true; but not the conclusion generally made, that this greater angular velocity of the interior particles necessitates a greater *linear* velocity. And it depends upon this *linear* velocity as to whether the rising AA currents will lag or not.

Suppose that in the sun, where the equatorial surface has a linear motion of over 100,000 miles a day, all particles between the equator and the center had the same linear motion of 100,000 miles a day. Then a particle ten miles off the center would make 43,000 rotations around the axis while the surface made but one—a proportion quite impossible, showing at once that the interior layers cannot have the same *linear* velocity as the surface, and far less a higher one. Such assumption would lose sight of the strong friction between the concentric layers inside the sun, *which tends to make all these layers move with the same angular speed*, as in a grindstone.

Such uniform angular speed (which naturally excludes a uniform *linear* speed) would indeed be a matter of fact if the sun had no radiation. Radiation, however, tends to bring about just the opposite state. It creates convection currents and these bring the slow-moving lower masses up into the upper regions of quick motion, and vice versa—tending to give them all the same *linear* speed of rotation.

Thus, the two factors work counter to each other; the one, the action of the currents, tending towards uniform *linear* velocity, while the other, the friction between the concentric layers, tends towards uniform angular velocity. As a result of these conflicting tendencies the interior masses have greater angular but smaller linear velocities than the surface of the sun's body—precisely as assumed in the text above.—This conclusion may not be admitted, as it seems to run counter to the so-called law of areas—which law manifests itself by the motions of the planets, the moons, and the millions of small satellites constituting Saturn's rings, all of them revolving not only with greater angular but with greater linear velocities, the nearer they are to the center of their primaries—and it may seem logical that this law ought to rule inside the sun as well as outside of it. But this conclusion would be wrong. The law is right enough for celestial bodies moving free in space, governed only by the forces of attraction and gravitation, *but not for a coherent gas ball, where other forces come into action, such as radiation, convection currents, and concentric friction.*

I repeat, the "concentric friction" in a rotating gas ball or lens tends towards uniform angular velocity, giving the surface a greater linear speed than the interior parts. The convection currents have the contrary tendency(impossible to be fulfilled) of giving the central and the interior parts *the same* linear speed as the surface—but by no means a higher one. From the coaction of these two tendencies we arrive at the fact that in a rotating gas ball or lens it is the surface which moves the quickest (the outer edge of each axial section having a greater linear velocity than any of the section's inner parts) and that, therefore, the rising AA currents, coming from slower-moving regions into regions of greater linear speed, must lag behind their surroundings —a conclusion which confirms the theory I started with. (The foregoing conclusion also does away with the view, entertained by some, that only the descending currents BB (Fig. 3) form distinct currents, the material which they take down from the photosphere being replaced from the surface material of the sun's body. This view would not agree with the considerable degree of angular velocity which the BB currents impart to the lower strata, nor with the "triangular flow" described before—which flow would take place even if the BB currents did not go down as low as the center.)

If "current views" were right in assuming a greater *linear* velocity for the interior masses, the currents AA would be curved the other way than shown in Fig. 3, *and would enter the photosphere in the opposite direction.* Then the equatorial surface would not be accelerated but retarded.

Super-Explosives

In a recent communication to *La Société suisse de Chimie*, A. Stettbacher dealt with the subject of explosives which are chemically or theoretically possible. To obtain the maximum production of heat from a combustible substance, it must undergo direct combustion in an exact quantity of oxygen. In the case of explosives, this condition is realized with "oxyliquite," a mixture containing liquid oxygen which develops 2,000 calories on combustion, as compared with 1,580 calories from nitro-glycerin. The ozonides of ethylene and benzene develop less heat than "oxyliquite," but their disruptive power is far greater—probably the greatest known. The highly unstable trichlorate of glycerol contains relatively more oxygen and greater endothermic energy than any other explosives, and its heat of explosion should be about 3,000 calories. Theoretically the most powerful of all would be a stoechiometrical mixture of liquid hydrogen and liquid ozone, 1 kilo. of which would liberate 4,500 calories. Although there is no strict comparison, it is worthy of note that in the disintegration of radium the energy set free exceeds the latter figure by more than 200,000 times.—*Rev. Gen. d. Sci.*

Russia's Industrial Losses

A Reuter message from Petrograd of April 11th, states that the Commissariat of Commerce has issued a summary of what Russia has lost by the peace treaty of Brest-Litovsk. The losses specified are: 73 per cent of the total iron production, 39 per cent of the total coal production, 268 sugar refineries, 918 cloth factories, 574 breweries, 173 tobacco factories, 1,685 spirit distilleries, 244 chemical factories, 615 paper factories, 1073 machine factories, 21,530 kilometers of railways (one-third of all the railways of Russia), 56,000,000 or 32 per cent of the whole population, and 780,000 sq. kilom. of territory.

Electrolysis Mitigation—I

Discussion of Causes and Methods of Regulation[1]

THE many conflicting interests involved in the electrolysis problem make it imperative that some sort of regulations governing the procedure of the various parties in interest be adopted if a permanent and just settlement of the problem is to be secured. It is true that conditions vary greatly in different localities, and always to attain a complete solution would require a separate investigation for each case. In general, however, it is not practicable to make a detailed engineering investigation of each locality, such as would be necessary in order to prescribe regulations especially adapted thereto. As in all other cases where diverse interests come into conflict the interests of all will be best safeguarded by the adoption by a proper authority of more or less specific regulations defining the responsibilities, rights, and limitations of the parties to the dispute.

The various factors which determine the electrolytic conditions of underground structures, such as overall potentials, and potential gradients in the track or pipe network, potential differences between pipes and tracks, and between various pipe and cable systems and the earth, current flow in the pipes, current density of discharge from the surface of pipes, etc., while important in any complete electrolysis survey, are for the most part subject to such a variety of influences that they are not suitable for use as a basis for regulations. The factors selected must not only afford a fair criterion of the general electrolysis situation, but they must at the same time be susceptible of easy measurement, and they must lend themselves to ready and fairly accurate predetermination, so that the railway return system can be designed to meet the regulations with a minimum of uncertainty.

All of the above-mentioned factors except the overall potential measurements, and potential gradients in the track return, are affected to a great extent by the character of the pipe systems, and changes in the latter may produce marked changes in most of the former; and hence these factors are only partially under the control of the railway company. Further, none of these other factors except the potential drops on the pipe systems afford an accurate criterion of the danger from electrolysis. They are therefore unsuitable for use as a basis of specific regulations designed to protect underground structures.

The overall potential and potential gradient measurements, on the other hand, particularly those taken in the pipe systems, afford practically as good a criterion of the danger existing when interpreted in the light of general experience as any other measurable factors. They are fairly definite, readily measurable, and in very large degree under the control of the railway company; hence they are best adapted for use as a basis of rules and regulations.

In all laws and regulations that have up to the present time been adopted, so far as we are aware, the overall potentials and potential gradients have been specified as those taken between various points on the railway tracks. This is true of the various European ordinances as well as those adopted in this country. These are very good criterions in many respects and have proven successful, particularly in Europe, in relieving electrolysis troubles. There is much to be said, however, in favor of limiting potential drops on the earth or on pipe networks rather than on the railway track. Such voltages afford the most accurate criterion of all, as to the actual danger to the underground structures, and would also prove more advantageous to the railway companies.

If potential drops on the earth or pipes be made the subject of limitation, higher voltages could be allowed in those tracks having a high resistance to earth. This would apply to tracks laid on a well-drained roadbed, for example, and with still greater force to tracks on private right of way where the rails are set up on ties out of contact with the earth. On the other hand, relatively low voltages would have to be maintained in tracks in which the rails are much of the time in intimate contact with moist earth, or otherwise constructed so as to give a comparatively low resistance to ground. Under this plan low voltages in the track would be required only where most needed and the railway company would be encouraged to so construct the tracks as to give a high leakage resistance to ground. It is evident that if the leakage resistance to ground be made high, practically all of the current will be compelled to return to the negative bus by way of the railway negative return and thus increase the voltage drop on the tracks, although reducing electrolysis troubles. If, however, the voltage drop on the tracks is limited by regulations any construction of roadbed that would reduce leakage would increase the difficulty and cost of complying with the regulations. On the other hand, if the voltage drop on the pipes is made the basis of the regulations, the railway companies would profit by any construction which tends to reduce leakage instead of suffering by it, as in the case where voltage drops in the tracks are limited. If this plan were adopted, it would of course be necessary to prescribe lower voltage limits than would be applicable to tracks in order to secure the same freedom from electrolysis.

VOLTAGE LIMITS IN TRACKS

(a) *Previous Experience Regarding Voltage Limitations.*—In this country little experience has been had until recently with railway installation in which voltage drops in the negative return have been maintained low enough to give substantial freedom from electrolysis trouble. The prevailing practice in a majority of the cities of America has been to permit rather high voltage drops in the return circuit, and it is for this reason mainly that electrolysis troubles have assumed much more serious proportions in this country during the past decade than in almost any other country. There has, therefore, been but little experience in this country that can be used as a reliable guide as to just what voltage limits can be considered safe, although there is abundant and incontrovertible evidence in regard to what voltage limits may, under many circumstances at least, be considered unsafe.

On the other hand, in Great Britain and many parts of continental Europe much experience has been had with installations in which quite low voltages have been maintained over a period of many years; and this long experience has shown that the voltages which have been maintained in these countries are such as to insure, under average conditions, substantial freedom from electrolysis. This experience, therefore, is a valuable guide in determining what voltage limits can be considered safe under similar conditions here.

(b) *Voltage Limits Prevailing in Great Britain.*—In Great Britain the maximum allowable voltage drop between any two points of any railway system, near which underground metallic structures are laid, is limited by law to 7 volts. This law has generally been complied with by the railway systems of Great Britain, and where this 7-volt limit has been substantially complied with there has been comparatively little trouble from electrolysis of underground structures.

In some instances this legal limit has been considerably exceeded, due primarily to the fact that the British Board of Trade, which is charged with the responsibility of administering the law, has not made it a practice to make investigations of electrolysis conditions on its own initiative, but only on the complaint of interested parties. For this reason isolated cases can be found in which the prescribed voltage limits are for a time exceeded, and it is doubtless due largely to this fact that most of the electrolysis trouble, that has been experienced in Great Britain, has occurred. On the other hand, in many cities in Great Britain the limits prescribed by the ordinance have not only been met, but the prevailing voltage drops under ordinary traffic conditions have been found to be considerably below the maximum limit prescribed by law.

The accumulated experience with the voltage limits which prevails in Great Britain appears to show quite conclusively that voltages of the order of the magnitude of those maintained in the railway systems there are none too low to assure adequate protection to underground structures; and it is the opinion of some competent engineers that even lower limits are desirable and commercially practicable. This attitude was taken by the engineers who drew the regulations that are now in effect in many cities of continental Europe.

(c) *Voltage Limitations in Germany.*—The so-called German regulations, which are in effect in many cities in continental Europe, while differing radically in the manner in which the voltage limits are defined, were designed by the framers of the regulations to yield somewhat lower average voltage conditions than those demanded by the British law. The German regulations prescribe a voltage limit of 2½ volts throughout any city network of street railway lines, and they further prescribe a limit of 1 volt per kilometer (0.3 volt per 1,000 feet), on interurban lines. These limits are applied to the period of average scheduled traffic instead of to the peak-load period, as in the case of the British law.

In both of these sets of regulations, the definition of voltage limits is indefinite and unsatisfactory. The British law limits the maximum drop to 7 volts, but does not specify whether it is the momentary maximum that is subject to limitation, or the sustained maximum during some definite interval of time. In applying the law, however, the British Board of Trade has found it necessary to adopt for administrative purposes a more specific definition of the term "maximum voltage." In determining this maximum voltage, the average value for the half hour of highest load is determined, and also the maximum momentary drop during this period, and the mean of these two values is taken as the maximum voltage within the meaning of the law.

In the German regulations a similar ambiguity exists. While it is stated that the voltage under average scheduled traffic should not exceed certain values, it is debatable whether or not it is intended that the momentary value of voltage drop under ordinary schedule traffic is to be kept within the prescribed limit or whether the average value of voltage drop under normal operating conditions is the value to be considered. If we place the latter interpretation on the question, the limit appears to be reasonable and practicable, and one that would, under many circumstances, be applicable in this country. If, however, it is intended to limit the momentary voltage under average load conditions in street railway networks to 2½ volts, the regulation would be altogether too severe for general application, as a voltage limitation of this severity is not needed for providing reasonable protection to underground pipes and the cost of meeting such limitations would be altogether out of proportion to the benefits that would accrue therefrom.

If we assume, then, that this overall voltage limit of 2½ volts is to be taken as the average value under normal scheduled traffic, it would be found to compare very well, so far as ultimate results are concerned, with the voltage limits in effect in Great Britain. It will be apparent that the maximum value of 7 volts, defined as the mean value between the average for the maximum half hour and the highest momentary value for that hour would correspond to a mean value for the maximum half hour of approximately 4 to 6 volts under most traffic conditions. On a basis of 50 per cent load factor, this would give a mean value under average load conditions of 2 to 3 volts, which is of the same order as the 2½ volts average limit named in the German regulations.

The above discussion relates only to the overall voltage limits prescribed by the regulations in question. The German regulations make no provision for restricting the potential gradient within the city network proper, the gradient limits of these regulations applying only to interurban lines. The British law, however, contains a provision which limits the current density in any street railway rail to 9 amperes per square inch of cross-section. This, in effect, prescribes a potential gradient limit, which, however, is variable according to the resistivity of the rails; and for rails of average resistivity this gradient limit would yield a maximum potential gradient of approximately 0.9 volt per 1,000 feet, exclusive of the drop on the joints. This would correspond to an average all-day gradient of from 0.3 to 0.4 volt in the case of most railway loads.

It is very desirable to have both the overall voltage limit and the potential gradient limit, the latter to prevent too rapid change in the potential of the tracks in any locality, which makes it difficult to prevent large potential differences between pipes and rails from developing locally, and the former to prevent the use of excessively long feeding distance, which, even with a small gradient, would permit the accumulation of large potential differences between pipes and tracks.

(d) *Manner of Specifying Voltage Limits.*—As to the manner of specifying the limiting voltages that should be allowed, there is a good deal of difference of opinion. Some prefer to specify a limit for momentary voltages, and others advocate restricting the maximum value for some definite short period, such as 10 to 30 minutes during the peak-load period, while many prefer to follow the practice of specifying an upper limit for the average voltage during the operating period. We have become convinced that the last plan is in general to be preferred.

Our investigations have shown that the actual amount of corrosion which takes place is much more nearly proportional to the average all-day load than it is to any short-time peak value. In fact, investigations made at the Bureau of Standards[2] show that as the load increases and the current density is thereby increased the actual corrosion does not increase as fast as the current increases. For this reason it is undesirable to place a heavy penalty on a high peak of short duration, provided the average current is small. This objection is avoided entirely by specifying the average value of the voltage instead of some short time peak-load value.

[1] From a Technological Paper issued by the U. S. Bureau of Standards.

[2] Burton McCollum and K. H. Logan, "Electrolytic corrosion of iron in soils. Bureau of Standards Technologic Paper No. 25.

To specify a limiting value of voltage during from 10 to 30 minutes would probably not be a serious matter in the case of a congested city district, where the railway loads are comparatively steady and the load curve shows a comparatively flat maximum. In case of suburban or interurban lines operating an infrequent schedule, particularly where multiple car passenger trains and heavy fright trains are operated, any short-time voltage limitations will almost always impose upon the railway company a hardship that is altogether out of proportion to the benefits that could possibly result from such a method of defining the maximum.

In the case of interurban railway systems, any voltage limitations based upon momentary maximum values would be practically prohibitive, unless the voltage limit were placed so high as to be of no real value for general adoption. It seems best, therefore, that any voltage limitations that may be applied be based upon the all-day average value of the voltage rather than on any short-time period. Investigations have shown that if the polarity of the pipes reverses frequently, as, for example, every few minutes or oftener, the actual amount of corrosion which results is practically proportional to the algebraic average value of current due to the fact that for short periods of reversal the corrosive process is in large degree reversible. If, however, the frequency of reversal is very low, the reversal taking place once an hour, or at longer intervals, the corrosion increases and tends to become more nearly proportional to the average value of current during the time when the pipe is positive to earth, the average being of course reduced to a 24-hour basis.

Owing to the uncertainty of the length of the periods of reversal that may occur under average operating conditions, it is best in fixing voltage limits in practice to base the limiting values on the 24-hour average value of voltage during those periods when the pipe frequently becomes positive to earth. In interpreting the significance of voltage readings actually taken, however, where the frequency of reversal is always approximately known, it is best to bear in mind that for periods of reversal of a few minutes or less the algebraic average affords a better criterion of the damage that will result than the arithmetical average.

A careful study of the local conditions in this country, in the light of the extended experience in European countries with the voltage limits that have prevailed there for many years, indicates that the average all-day voltage drop in the railway tracks under average conditions should be restricted to a value not exceeding about 2 to 4 volts, the lower value applying to localities such as business centers in large cities where the underground utilities are highly developed and of great value, and the higher value to those regions in which the utilities are developed to a lesser extent, such as the average residential districts in cities.

In very sparsely settled districts still higher voltage drops may be permitted, and in many cases, especially where tracks are on private right of way and substantially insulated from earth, throughout their entire length the voltage limits may even be dispensed with altogether. Thus, in fixing regulations for any given city, some sort of a zone system is desirable, different voltage limits being prescribed for different zones, according to the value of the underground utilities and other local factors.

These all-day average values of 2 to 4 volts would, in the case of the majority of railway loads, correspond to an average during the maximum hour of from 3 to 10 volts, there being a greater variation in the values for the shorter than for the longer period. The average gradient corresponding to this overall limit will depend in large measure on the means that are adopted for complying with the limitation and on the feeding distance. A study of the best methods available for reducing voltage drops indicates that the average 24-hour gradient at any point in the rail should under average conditions not be permitted to exceed about 0.3 to 0.4 volt per 1,000 feet.

These limits of 0.3 to 0.4 volt per 1,000 feet for the 24-hour period correspond roughly to 0.4 to 0.5 volt per 1,000 feet for the 18-hour operating period. If the drop of potential on pipes or earth is made the basis of limitation, lower values would have to be used. Experience indicates that, on the average, overall potentials and potential gradients in the earth should be maintained at about one-half the figures given above in order to insure the same freedom from electrolysis.

We do not wish to be understood as taking the view that the average voltage for the maximum hour or even half hour can not be made a satisfactory basis for voltage regulation. Experience has shown that either plan can be made to work out very well in practice. Recent investigations, however, show that the use of the longer period is a more rational basis of fixing voltage limits, since it gives a factor which is more nearly proportional to the actual danger involved than any other. Cases continually arise in the operation of street railway systems where local traffic congestion will cause very excessive voltage drops locally for short periods of from 5 to 15 minutes or longer, but these occur so infrequently that they have but slight effect on the average all-day values, and hence on the total damage from stray currents.

To adopt any rule which would limit these transient rises of voltage to very low values would involve an expense to the railway company which would be out of all proportion to the benefits that would accrue to the owners of underground utilities. On the other hand, if the voltage limit is placed high enough so that it can reasonably be applied to lines having very heavy transient loads, it would be altogether too high for other lines having comparatively steady loads. If the all-day average value is used, however, the cost of meeting the limit, as well as the degree of protection, will be independent of the character of the load on different lines.

[TO BE CONTINUED]

The Castor-Oil Plant

Of late there has been considerable inquiry as to the cultivation of oil-yielding plants, including the castor oil. There is ample evidence that this plant will thrive almost anywhere on the coast lands of Queensland. In and around Brisbane, the *Queensland Agricultural Journal* states, it may be seen growing and bearing heavy crops of seed in all sorts of out-of-the-way places—on the river banks, in quarries, on unoccupied allotments, etc.; and this applies as well to other coastal localities in Central and North Queensland. No attention has, however, been given to it with a view to turning a plant which is looked upon almost as a noxious weed to profitable account. Most people, especially children, know to their sorrow that castor oil is a most valuable medicine; but not many are aware of the large quantities which are used for lubricating machinery and for illuminating purposes. In India it is used on all the railways in the signal and carriage lamps, owing to the brilliancy and safety of the light. It burns very slowly, and thus is more economical than other oils.

The plant is exceedingly hardy and will stand a wide range of climate. The seeds have extraordinary vitality. Oil seeds, as a rule, quickly lose their germinating power; but the castor seed seems to be an exception. Seeds known to have been kept for fifteen years in a bottle have been sown in Queensland, and have produced healthy plants. In a tropical or even subtropical climate the plant becomes a perennial tree instead of an annual, attaining a height of from 20 to 30 feet. The best soil for castor is much the same as that required for the cotton plant—a rich, well-drained, sandy loam. It will not thrive on heavy, wet soils. As the roots penetrate very deeply, the land must be deeply ploughed and well worked. The seed is planted in rows 6 to 8 feet apart each way, three or four seeds being planted in a hole. Before planting they should be softened by having hot water poured over them, and then being left to soak for twenty-four hours. In ten days after sowing the seeds will germinate, and when the plants are 8 to 10 inches high the three weakest must be taken up where four seeds have been put in. They grow very rapidly, and begin to bear in four months. Like the coffee and cotton plants, the castor plant would grow to an inconvenient height if left to itself. It should, therefore, be kept low by pinching back the main stem. This will have the further effect of causing the plant to throw out many more fruit spikes than it otherwise would do. When the tree gets old, the usual scale insect (the *Coccus*) attacks the bark. They have to be dealt with, as in the case of citrus and other fruit trees, by spraying with kerosene emulsion.

When the capsules turn brown it is time to begin the harvest. This is done by cutting off the spikes and removing them as soon as possible to the barn. The work of harvesting must be done rapidly, for if the seeds are allowed to ripen on the tree the pods burst open and the liberated seeds fly in all directions. This "popping" of the capsules makes the matter of freeing the seeds a very simple one. All that has to be done is to prepare a drying-ground either in a shed or in the open. The ground should either be boarded or swept quite clean. When the spikes are brought in they should be spread out on the drying-ground to the depth of from 6 inches to 1 foot, according to the heat of the weather. Should rain occur when out-of-door drying is being carried on, draw the spikes into heaps and cover with a tarpaulin. Turn the spikes over frequently to let all get the benefit of the sun. The capsules will soon begin to burst, and in four or five days they will have shed all their seed. All that remains to be done is to sift or winnow out the husks. When drying in the open, it is well to surround the drying spikes with a low rampart of galvanized iron or bagging, for the reason that many seeds fly out very violently, and without some such precaution they would be lost.

The return from an acre is about 20 bushels, a bushel of seed weighing 46 pounds.

In India the seed is crushed between rollers, placed in hempen cloths, and pressed, and then the oil is heated with water in a tin boiler until the water boils. This separated the mucilage and albumen, the product being finally strained through flannel.

Cheap wooden rollers would serve the purpose, and these could be driven by a horse gear.—*The Colonial Journal.*

Peat as a Fuel

Peat is disintegrated and partially decomposed vegetable matter—vegetable mud. It collects in and fills up swamps under favorable conditions. Vast deposits of it are known in temperate and cold climates. It is not found in warm localities, for there the decay of vegetable matter is too rapid. The formation of peat illustrates the conditions under which coal originates. The rate of growth of a peat bog is often from one to four inches a year, the depth varying from ten to twenty feet. When dried in the open air peat forms a valuable domestic fuel, and its value is greatly enhanced by compression into small blocks or briquettes, whether alone or in mixture with coal dust. In times and countries where the forests could not supply sufficient fuel, men have turned to peat to take the place of wood for burning. Its greatest importance seems to have been in the eighteenth century, when the forests of northern Europe had been to a great extent cleared away and the use of coal had not yet become general as it was later to do when transportation facilities were to make distribution practical. At that time peat was used for household purposes by the rural populations of northern Germany, Scandinavia, Russia, France and the British Isles. In Ireland particularly peat was and still continues to be a much relied-on natural resource. Yet the supply from European bogs, though drawn on for many centuries, seems never to have approached exhaustion, due no doubt to the fact that under favorable conditions accumulations of peat are renewed from two to three feet in the course of thirty or forty years.

Peat was burned to some extent in the United States during Colonial times and even later, until the progressive cheapness of anthracite coal led to the abandonment of local fuel. But the present generation of Americans does not know the extent of the peat deposits in this country or their value. It has been estimated that there are 15,000,000,000 cubic feet of peat in Massachusetts alone, while the Great Dismal Swamp of Virginia and North Carolina, forty miles long by twenty-five miles wide, is practically an inexhaustible storehouse of the material. Peat is found along the coast of New Jersey and south along the Atlantic coast to the central parts of Florida, and along the Mississippi and other rivers with well-developed inundation plains. There are also deposits west of the Mississippi, but these become more and more scanty as one journeys westward, and are of little economic value. By far the richest deposits of this country lie in New England, east of the Berkshire Hills and Green Mountains. Going inland from the seashore the peat bogs decrease in quality as fuel, but their value as fertilizer increases. The enormous deposits in Canada and the United States have been little used, save in Canada, where compressed peat is a product of the closing decade of the nineteenth century.

Peat has been commercially unsuccessful in the past due to its bulkiness, which makes it difficult of transportation, and to the cheapness of coal. By various devices, however, there can be produced from this vegetable mud a compact material fairly comparable in quality with lignite or the poorer bituminous coals. Charcoal made from compressed peat is superior to wood charcoal and even compares favorably with coke. That obtained from uncompressed peat is used to temper cutlery, etc., and as a deodorizer and antiseptic. In agriculture, too, peat is important, for three reasons, it makes good fertilizer, is valuable as an absorbent material when mingled with refuse, and helps to retain mositure when mixed with dry, sandy soils. —Public Information Committee of the American Museum of Natural History.

Shoes

There is no need of any special orthopedic shoe, asserts a writer in the *Medical Review of Reviews*. The patient should procure any comfortable shoe in which he is able to move all his toes freely. If we are handling a case of weak foot the inner one-half of the soles and heels can be raised one-quarter to one-half an inch by the cobbler and then the patient has an excellent shoe without any additional expense. This addition is not for the purpose of raising the arch but to make the patient walk more on the outer border of his foot which in turn tends to bring the foot to the normal plane.

Ironing Out Cracks in Iron

Electrical Method of Eliminating Fatigue of Metals

A METHOD of renewing crystallized metal pipe is in vogue in California that is as successful as it is radical. And it is a method that should be of very real interest to all central-station companies. The method referred to is that being employed by the Bardeen Corporation at Brea, California. The method consists of heating casing, tubing and drill pipe in the oil fields electrically, or when desirable by means of other sources of heat. Electricity is the most satisfactory, efficient and in all ways superior, except in that item of cost.

Considerable pipe and metal is lost annually in the oil fields due to crystallization, becoming brittle and twisting so that it breaks. The result is loss of time and material, loss of money, since the metal is sold as junk, and reduced production of the wells while changes are being made. By the following process, junking of drill pipe may be a thing of the past, as by this process it is claimed pipe may be made over to a condition as good as new at low cost.

Steel which has been subjected to repeated shocks will break easily and the fractures show a crystalline appearance, due to repeated stresses which occur therein. The crystals are in the steel at the start and the shocks to which the steel is subjected do not form more crystals nor do they materially modify those that already exist in the steel. What happens is that as the steel is repeatedly stressed, either by bending, pulling or twisting, it becomes fatigued. This fatigue is probably merely the first stages of an infinite number of small cracks or tears in the body of the steel and these tears naturally tend to occur along the faces of the crystals of the material, at first of microscopic dimensions that do not materially weaken the metal. As they spread they greatly weaken the metal, which eventually parts along the crystal faces, and the characteristic fracture, which is referred to as crystallizations, occurs.

Before this state of fatigue continues sufficiently to weaken the metal materially, or in other words if it is taken in time, it can be partly arrested by heating the material to a welding heat. But the mere heating, while it tends to stop the cracks from spreading and while it may rearrange the crystals so that some of the cracks are partly closed, is of little value unless it is done early, and in fact before much of this tearing away of the metal occurs. A badly fatigued pipe cannot be restored to its original strength by merely heating it.

The Bardeen process not only heats the pipe, but also involves the application of longitudinal pressure. In the first place, during heating the pipe has heavy spring pressure on its ends so that there is a constant pressure of about 3,000 pounds on it in the direction of its length. As the pipe is heated to a carefully regulated temperature this pressure tends to squeeze the pipe together and to repair any small cracks running around the pipe. This it does just as a blacksmith makes any weld, namely, by heat and pressure. It is true that the blacksmith hammers the metal, but that is merely his way of getting pressure. In big steel mills the idea of hammering metal is gradually being done away with and large hydraulic presses are coming into very general use for forging steel. The spring pressure of the Bardeen process is an important factor, but not the most important one.

In the process electricity is used as the heating medium and, while somewhat expensive, is necessary for reasons which will be later pointed out. The first great advantage of the electric method is that each joint can be heated separately and the heat carefully controlled. In practice it requires something over fifteen minutes in which to heat a six-inch pipe twenty feet long and during the heating the operator is able at all times to observe the pipe, which rests on a flat surface and is covered with a light asbestos hood. By heating it electrically and slowly the joint is very evenly heated throughout its length and has a chance to expand slowly. As soon as the pipe reaches a desired temperature the heating operating is shut off instantly. As during the heating operation the current actually flows through the pipe and the heat is generated in the body of the pipe, this heat is evenly generated throughout the body of the metal, and as all the losses are on the outer and inner surfaces it follows that these surfaces are the cooler. Considering the pipe as a plate, it will be seen that the surfaces of the plate are cooler than the interior. It is highly probable that this unequal heating through the thickness of the material causes a working which helps to weld the cracks and arrest the fatigue. It is not this feature which makes the process a success, however, but the electromagnetic action which is taking place simultaneously.

To understand this action it must be understood that, with the very heavy current used, the magnetic effect is very marked. Large spikes will hang on the woodwork surrounding the pipe and a crowbar is pulled into the magnetic field anywhere around the pipe. This external or stray field is small as compared to that which flows through the pipe itself, however. The magnetic lines of force flow in a plane at right angles to the direction of current flow—that is, as the current flows along the pipe the magnetic lines flow around it. It is easy to calculate that the steel of the pipe is saturated with magnetism. It is, further, easy to calculate that the force exerted, which is in effect a squeezing of the pipe together, is in excess of three hundred pounds per square inch. In other words, the magnetic pull in the body of the material is at least three hundred pounds per square inch. Under this enormous pressure any cracks are "ironed out" and the material of the pipe rewelded over the cracks. Moreover, if the pipe is treated on alternating current, this magnetic pull is applied and released from eighty to one hundred times a second. As the pipe is under this pressure, which is working constantly for from fifteen to twenty minutes, it is not surprising that after being cooled it fails to show any evidence of fatigue.

Now, it will be seen that this electrical process differs from ordinary annealing in several ways.

Firstly, there is accurate temperature control. By using a pyroscope or optical pyrometer in the hands of a carefully trained man the proper temperature at which to heat pipe to get the best results is exactly obtained and not exceeded. Any such scientific and accurate control would be impossible without the use of the electric current.

Secondly, during heating the pipe is under considerable axial pressure; in fact, the pressure lengthwise on the pipe is about 600 pounds per square inch of pipe section. This longitudinal pressure is sufficient to squeeze the pipe together lengthwise and eliminate a large part of the small cracks.

Thirdly, at the same time the circulating magnetic fluxes are busy kneading the whole mass of material of the pipe and closing up and welding out any cracks which may extend lengthwise to the pipe.

—The *Electrical Review*.

Ant Pests and Ant-Eating Animals*

THE ant-eaters are close kin to the sloths, but they live on the ground also, whereas the sloths live on trees. The ant-eating animals comprise the great or maned ant-eater, (*Myrmecophaga jubata*); the lesser ant-eater. or tamandua (*Tamandua tetradactylus*); the two-toed ant-eater, (*Cyclopes didactylus*); the armadillos; the pangolins; and the aard-varks. These six groups of animals are usually all classed under the order of the edentates, although they differ widely from one another in many respects. The ant-eaters and armadillos are Central and South American animals; the pangolins and the aard-varks are Afro-Asiatic.

The main point of interest common to these animals presented for consideration here is the fact that they devour ants, and that they may possibly be put to a useful economic purpose because of that fact.

The extent to which farming and gardening in Panama is handicapped by the presence of certain species of ants is a fact well known to everybody who has had the least experience in the matter. The difficulty of getting rid of the insects within the limits of the expense that could be borne is almost unbelievable unless one has tried it. The main reason for it lies in the marvelously intelligent routine habits of the ants. They have their central fortress, which is their home, food warehouse, nest, queen's palace, all in one; and from this center they have their long marching lines of workers and soldiers moving along in a continuous circuit to the trees or shrubs which they attack, and back again to their base; this being so continuous a movement that if one followed up the line outside of the nest in the ground and mashed them all, there would still be immense numbers of them in the subterranean galleries and chambers; while if the latter were blown up, and the lines left outside, there would be a sufficient number left outside for them to go off and start a new colony. Moreover, the minute a disturbance starts they scatter round so that it is almost impossible to get them all. They are extremely suspicious and wary; it is almost impossible to poison them, or to get them on sticky substances, or to trap them; while the usually prescribed use of carbon bisulphide has not been either completely efficacious or cheap enough to meet the requirements.

Of course it is possible for men to beat ants. By using dynamite, or the wholesale application of poisonous liquids or gas, or even by persevering digging and killing, they can be eliminated, but to get rid of a single well-developed colony by any or all of these methods would cost not less than ten or fifteen dollars, sometimes much more. Some of these colonies honey-comb the ground over an area of a hundred square yards and to a depth of two yards, thus requiring the excavation of two hundred cubic yards of earth to get rid of the nest.

The damage they can do is amazing. A colony has been known to strip an avocado tree in a day; another to destroy a hundred hills of yam-vines in the same time. Any kind of produce which they like cannot be raised near the nests; and their tastes are unfortunately very much like man's.

The possibility of using the ant-eating animals to combat these pests is therefore interesting. I am not aware that it has ever been done, and do not know how such an experiment would work out in practice. But ant-eaters would feed themselves on the work; they are known to tear the hardest and toughest nests all to pieces to get at the larvae, and in this way they also expose and probably destroy the queens. They could be harnessed so as not to interfere with their working powers, and as they also eat other insects they could be kept at little expense when not eating the ants, though there are ants enough to keep a good many busy all the time.

All this at least would warrant the capture and preservation of any ant-eater found here. Armadillos are fairly common, and all three of the ant-eaters are found in Central America.

*By S. P. Verner in the Panama *Star and Herald*.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK SATURDAY, JULY 20, 1918

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 4.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 1st, 1917, can be supplied by the H. W. Wilson Company, 958-964 University Ave., Bronx, New York, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 1st, 1917, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

Table of Contents

y 20, 191

ds and to a
ation of two
nest.
colony has
y; another
same time
t be raised
nately very

animals to
I am not
know how
ctice. But
; they are
eats all to
they also
They could
ir working
they could
nts, though
usy all the

e and pre-
nadillos are
are found

CAN

1918
porated
erse Beach,

Class Matter

s
r year $5.00
4.00
n countries
ation.
or check.
w York

publish
distin-
ant arti-
ons, and
thought
orld.

rican

January
son Com-
ork, N. Y.
son Com-
nd subse-
by Munn

e are in a
y branch
composed
rts, thor-
atent ap-
e of the
technical,

orld, who
mark ap-
e United

.,
itors,
adway,
rk, N. Y.